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COMPARISON OF TWO METHODS FOR ESTIMATING SOUND INTENSITY

Prepared under Contract No. NAS 8-11348 by

KAMAN NUCLEAR
KN-67-698-1

For

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER

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KAMAN NUCLEAR

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Aero-Astrodynamics Laboratory

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PREFACE

This report is the result of an effort to determine the advantages and disadvantages of present sound ray tracing techniques and to investigate the possible replacement of these with more exact procedures. As an adjunct to this investigation, an analysis of sound pressure levels was begun, also with an eye toward modifying or even replacing the present sound pressure level computation procedures with procedures of more exactitude.

The report is divided into three parts: background and theory, computer program, and results. By far the most interesting section is the one on results of the studies. In this section are to be found typical atmospheric conditions, along with analyses of these atmospheric situations, both by the present methods and by the methods as developed in this present report. Numerous comparisons are made between the two methods, with sometimes startling results. In order to fully understand this study and appreciate the results, one should study the preceding reports in this series. One deficiency is that no adequate, comprehensive "users manual" is given to ease the use of the computer program.

This work was done under contract number NAS8-11348 by Kaman-Nuclear under the technical Supervision of O. E. Smith, Chief, Terrestrial Environment Branch, Aerospace Environment Division, Aero-Astrodynamics Laboratory, Marshall Space Flight Center.

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SUMMARY

Obtained by ray-tracing methods, the diagnosed strength of noise fields depends partly on just the way in which the observed atmosphere is to be represented. Along the local vertical, a linearized variation of horizontal wind- and sound-speed introduces certain characteristics in the outward ranging of sound and its intensity. Such a straight-stepped representation of aerological data has been customary in meteorological practice, as a convenient approximation to the smoothly changing atmosphere. Descriptive of the real atmosphere, a non-linear representation of the aerological observations is nevertheless easily obtained. These representations lead to two methods for estimating sound intensity. This report discusses these methods and compares the results obtained by them.

CHAPTER I

CONSIDERATIONS IN PROGRAMMING SOUND INTENSITY ESTIMATES

CHAPTER I

The general problem consists in diagnosing and predicting the noise fields generated by the static firings of rocket engines. These fields vary according to the atmospheric conditions. In addition, from such firings, the outward ranging of sound may be affected significantly and undesirably just by the way in which the horizontal wind- and sound-speed is represented along the local vertical.

To assess this effect and then to account for it properly involves a number of important considerations (often overlooked), before the general problem can really be solved successfully. This chapter introduces the study-report of the general problem by stating what these prerequisites are and by showing exactly how they may be correctly satisfied.

To assess this effect it is necessary, for example, to preserve the derivative character of the landing distance of sound with respect to the initial ray inclination around data levels in the linear representation of wind- and sound-speed. The non-linear representation involves additional considerations. One involves the description of vertex coordinates in terms of the non-linear coefficients; another, the joining of the non-linear curve-segments for the best fit to the data points. These considerations prepare the way for the basic one, the integration of the ray equation.

The results are converted into computational relations which are introduced into the program for solving the general problem. This program is listed in Chapter II. Some results of its application are presented in Chapters III and IV. But, the primary purpose of this chapter is to facilitate the understanding of the program listed in Chapter II.

A. VERTEX COORDINATES IN TERMS OF PARABOLIC COEFFICIENTS

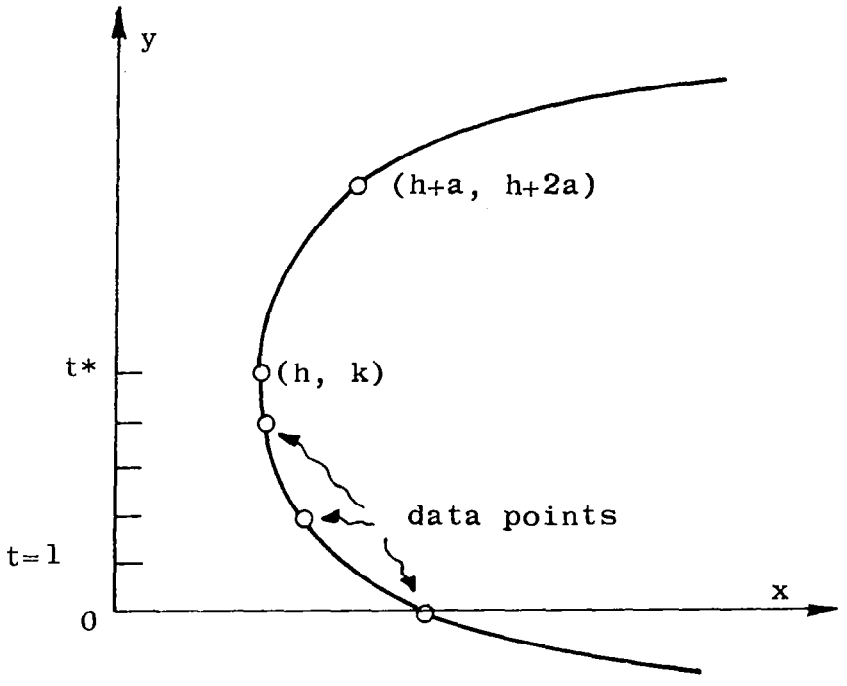

Figure 1
Atmospheric Sounding

Referring to Figure 1, we may transform the standard parabolic relation (whose symbols are defined in Figure 1)

$$(y-k)^2 = 2a(x-h)$$

to its normal form

$$x = A + By + Cy^2 \ .$$

Expanding equation (1) and rearranging to the form of equation (2) we have

$$x = \frac{k^2+2ah}{2a} - \frac{k}{a}y + \frac{1}{2a}y^2;$$

whereupon, from equations (2) and (3), we obtain

$$\left.\begin{aligned} A &= \frac{k^2 + 2ah}{2a} \quad , \\ B &= -\frac{k}{a} \quad , \text{ and} \\ C &= \frac{1}{2a} \quad . \end{aligned}\right\} \tag{4}$$

It also becomes convenient to transform equation (2) to the form

$$\left.\begin{aligned} x &= A^* + Q\,(z-z_*)^2 \quad , \text{ or} \\ x &= A^* + G^*\,(y-B^*)^2 \quad ; \quad \text{i.e.,} \end{aligned}\right. \tag{5}$$

equation (2) becomes

$$x = A - \frac{B^2}{4C} + C\left(y+\frac{B}{2C}\right)^2 \quad . \tag{6}$$

Comparing equations (5) and (6) we see that

$$A^* = A - B^2/4C \tag{7}$$

$$Q = G^* = C \tag{8}$$

$$z_* = B^* = -B/2C \tag{9}$$

From equations (4) and (7) it is evident that

$$B^2 = \frac{k^2}{a^2} \quad ,$$

$$\frac{B^2}{4C} = \frac{k^2}{a^2}\,\frac{2a}{4} = \frac{k^2}{2a} \quad ,$$

$$A - \frac{B^2}{4C} = \frac{k^2+2ah}{2a} - \frac{k^2}{2a} = h.$$

and by equation (7), it is seen that

$$h = A^*, \text{ and}$$

$$k = -(-\frac{k}{a})\frac{2a}{2} = -\frac{B}{2C}$$

and that, from equation (9),

$$k = B^* = z_* = (= t^*)$$

And $Q=G^* = C = 1/2a$ is the curvature of the parabolic sounding. For G^* positive, the parabolic apex is a minimum in, say, $v = c+u$; for G^* negative, a maximum.

In Figure 1 and equations (7-9) and these relations, x and y may be replaced by $v = c+u$ and t. Then equations (7), (8) and (9) become arithmetic statements 699+10, 11, and 12:

```
AA(1) = A1 - (B1**2) / (4*C1)

GG(1) = C1

ZZ(1) = -B1/2 *C1    .
```

The AA(1) is the sound-propagation speed v (m/s)at a vertex of the parabolic sounding-curve; ZZ(1), its height from sea-level. These vertex coordinates are expressed in terms of the parabolic coefficients. So, to find the vertex, or apex coordinates, we need to evaluate these parabolic coefficients. This may be done as follows

B. EVALUATION OF THE PARABOLIC COEFFICIENTS

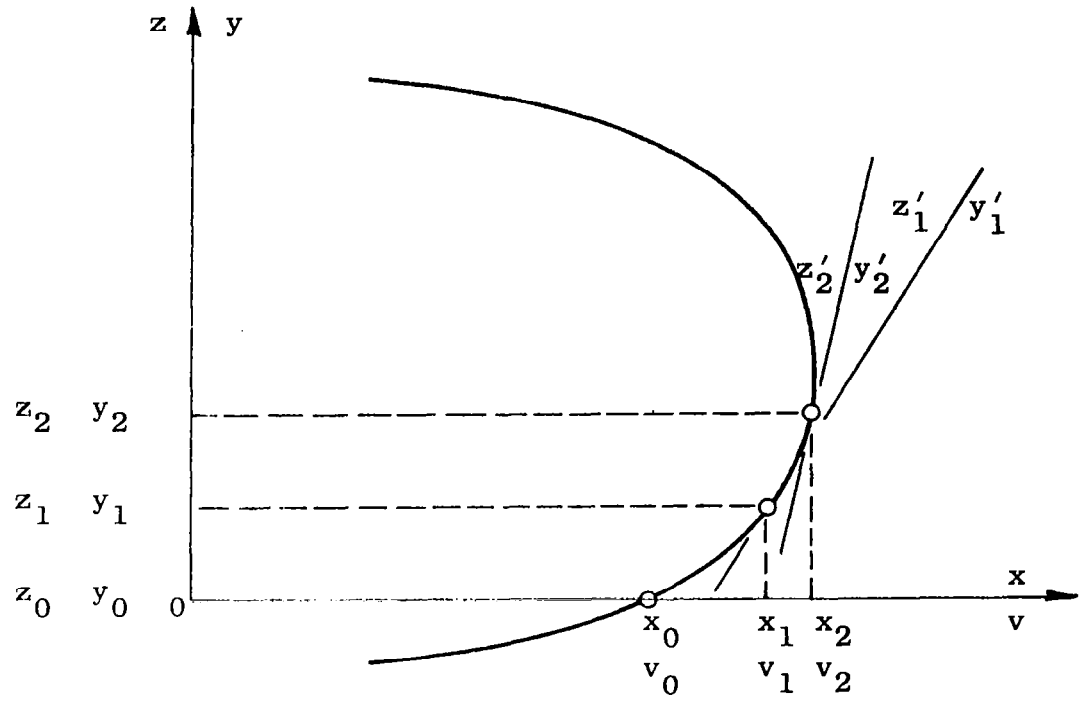

Figure 2

From equation (2) and Figure 2 - replacing y by z (for vertical z- coordinate), and x by v (for the horizontal v-coordinate)

$$x_1 = A + Bz_1 + Cz_1^2 \quad , \tag{10}$$

$$x_2 = A + Bz_2 + C_{z_2}^{\ 2} \quad , \text{ which, when} \tag{11}$$

differentiated, becomes

$$x_2' = \quad B + 2\,Cz_2 \quad . \tag{12}$$

Subtracting equation (11) from (10),

$$x_2 - x_1 = B(z_2 - z_1) + C(z_2^2 - z_1^2) \quad ,$$

$$\frac{x_2 - x_1}{z_2 - z_1} = B + C(z_2 + z_1) \quad . \tag{13}$$

And, subtracting equation (13) from equation (12),

$$x_2' - \frac{x_2 - x_1}{y_2 - y_1} = 2Cz_2 - C(z_2 + z_1),$$

$$= C(z_2 - z_1) \text{ ; whence}$$

$$C = \left(x_2' - \frac{x_2 - x_1}{z_2 - z_1}\right) \frac{1}{z_2 - z_1} \quad . \tag{14}$$

Equation (14) is arithmetic statement 699+7:

```
C1 = (F2P - FS) / DZ .
```

From equations (13) and (14)

$$B = \frac{x_2 - x_1}{z_2 - z_1} - \left(x_2' - \frac{x_2 - x_1}{z_2 - z_1}\right) \frac{z_2 + z_1}{z_2 - z_1} \quad ,$$

$$= \frac{x_2 - x_1}{z_2 - z_1} \left(1 + \frac{z_2 + z_1}{z_2 - z_1}\right) - x_1' \frac{z_2 + z_1}{z_2 - z_1} \quad ,$$

$$= \frac{x_2 - x_1}{z_2 - z_1} \frac{2z_2}{z_2 - z_1} - x_2' \frac{z_2 + z_1}{z_2 - z_1} \quad . \tag{15}$$

Equation (15) is arithmetic statement 699+8:

```
B1 = FS*2 . *Z2/DZ
     - F 2 P * (Z1 + Z2) / DZ
```

Finally, from equation (2)

$$A = x_1 - Bz_1 - C z_1^2 \quad ,$$

$$= x_1 - \frac{2(x_2 - x_2)(z_1)(z_2)}{(z_2 - z_1)^2}$$

$$+ \frac{x_2' (z_2 + z_1) z_1}{z_2 - z_1}$$

$$- \left(x_2' - \frac{x_2 - x_1}{z_2 - z_1}\right) \frac{z_1^2}{z_2 - z_1} ,$$

$$= x_1 + z_1 x_2' \left(\frac{z_2 + z_1 - z_1}{z_2 - z_1}\right)$$

$$- z_1 \left(\frac{x_2 - x_1}{z_2 - z_1}\right) \left(\frac{2 z_2 - z_1}{z_2 - z_1}\right) ,$$

$$A = x_1 + \left(z_2 x_2' - \frac{(x_2 - x_1)(2 z_2 - z_1)}{z_2 - z_1}\right) \frac{z_1}{z_2 - z_1} . \qquad (16)$$

This equation (16) is arithmetic statement 699+10:

```
A1 = F1 + (Z2 * F 2 P - FS *(2 * Z2 - Z1)) * Z1/DZ
```

C. OPTIMAL FITTING OF PARABOLIC CURVE-SEGMENTS TO DATA POINTS

In the previous report it has been shown that the parabolic curve segments mutually adjusted for best fit to the data points join one another midway between these points. So, in the code we introduce these half layers. For each data-and mid-point we express the height parameters and variables in the parabolic coefficients as multiples of the superjacent half-layer thickness as a height unit.

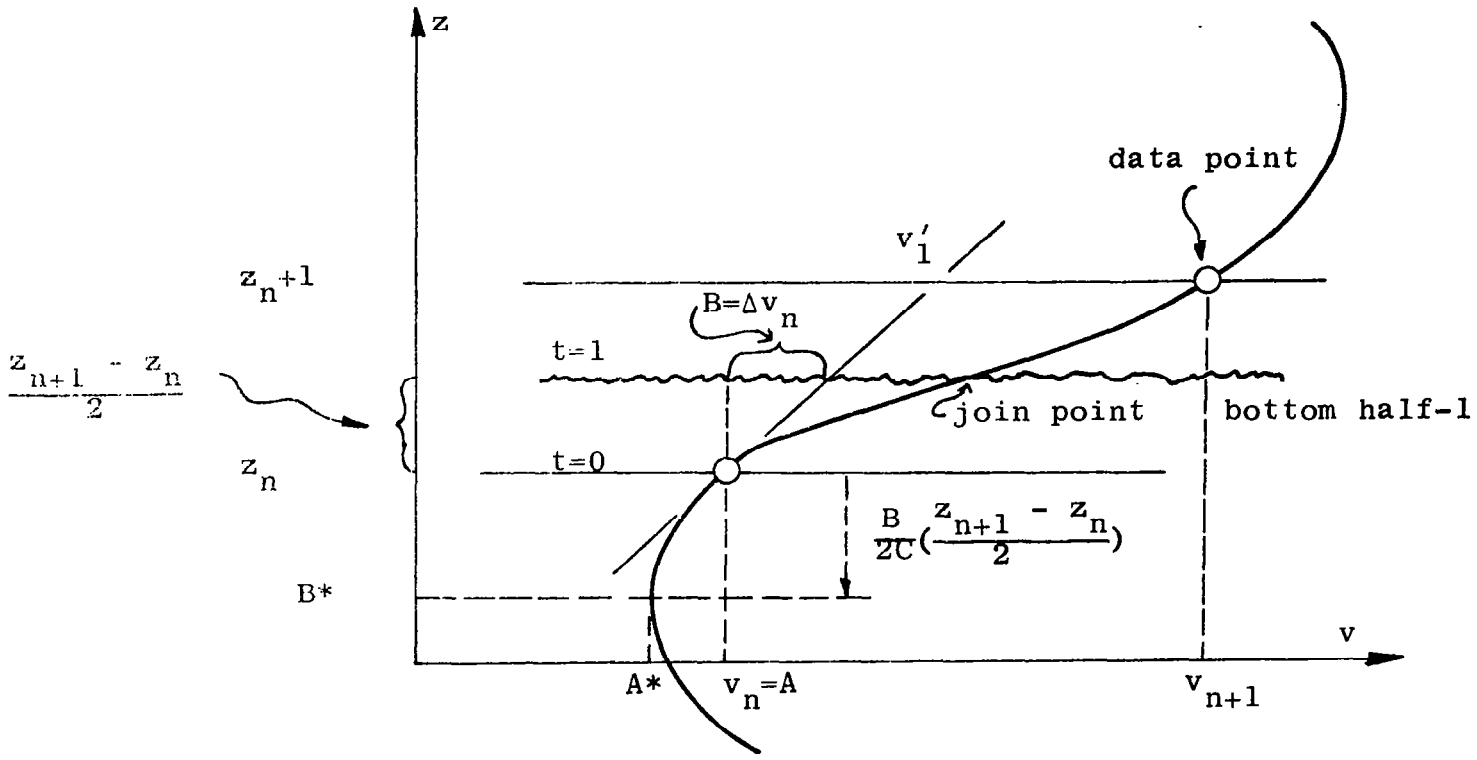

Figure 3

Consider first a bottom half-layer, as shown in Figure 3. There, the parabolic coefficients can be evaluated from observational data by the equations given on page 112 of the referenced report; viz.,

$$A = V_n \ , \qquad (17)$$

$$B = v_n' \ (z_{n+1} - z_n)/2 \ , \qquad (18)$$

$$C = \left[(v_{n+1}-v_n) - v_{n+1}'+3v_n')(z_{n+1}-z_n)/4\right]2 \ . \qquad (19)$$

Arithmetic statements 700-8 to 700-6 are obtained from these equations (17-19) respectively:

```
A1 = F1
B1 = F1P * DZ/2 .
C1 = (DF - (F2P + 3.*F1P) * DZ/4.)/2 .
```

Well away from their apex, the parabolic arms may become quasi-linear and, hence C = C1 approaches the value of zero. It is therefore necessary to introduce some device for keeping from getting C1=0. as the denominator of some of our expressions. We do this by testing for the near linearity of the parabolic arm a long ways from the vertex, as follows:

$$v = A + B\,t + C\,t^2 \quad (0 \le t \le 1) \tag{20}$$

$$v = B + 2\,C\,t \tag{21}$$

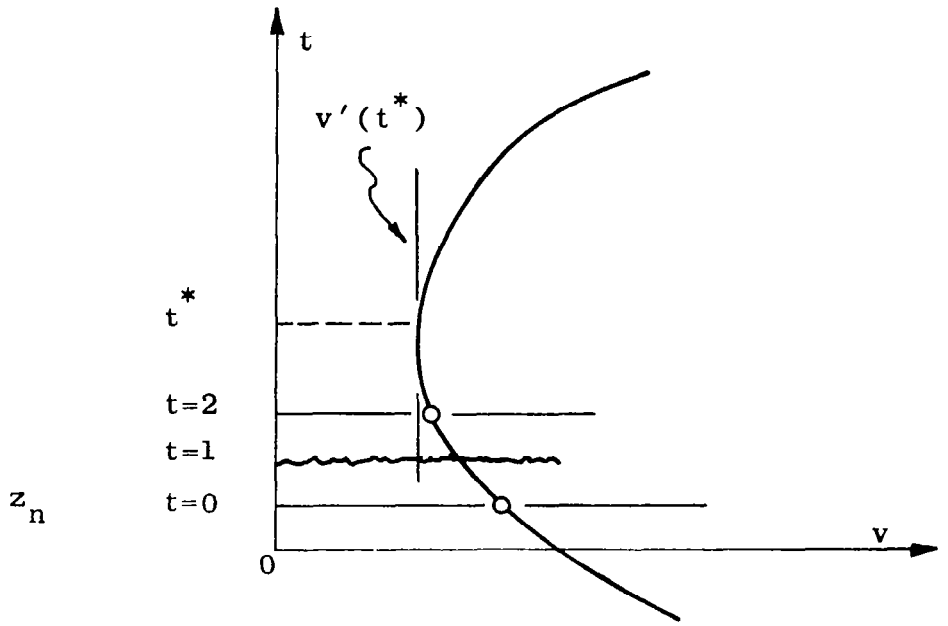

Figure 4

The t^* is the value of t which renders v' equal to zero (Figure 4). The t^* in equation (21) set to zero,

$$t^* = -B/2C ,$$

the distance to the vertex from the z_n-th level in half-layer units there.

$$\frac{C}{B} = \frac{-1}{2t^*} = \frac{1}{2x500}$$

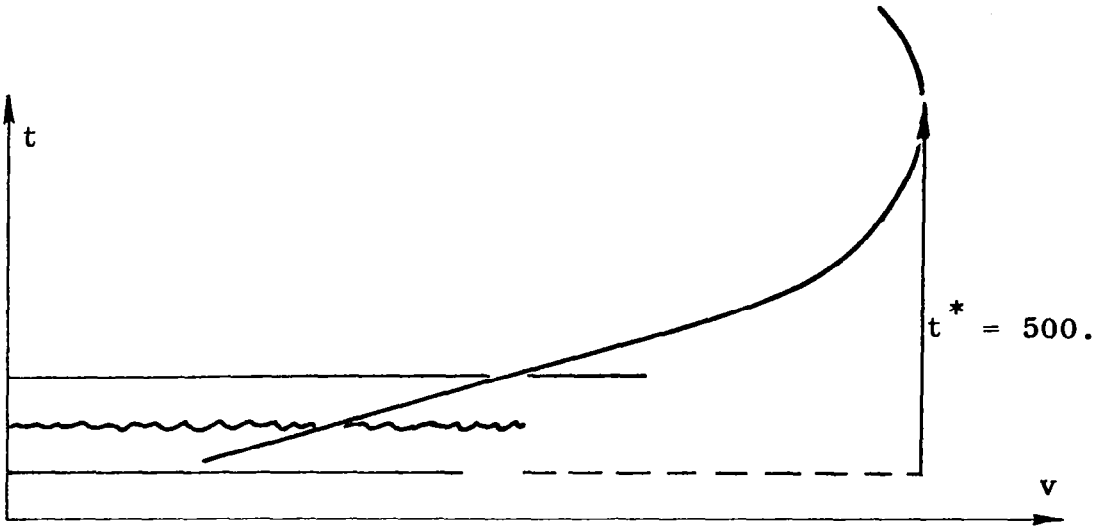

Figure 5

If C/B is numerically less than 1000; then a linear fit is to be called, the logic expression in 700-5:

IF (ABSF(C1/B1) . LT . 1 . E-3) .

From equations (17-19) we can obtain the vertex coordinates and the curvature. First, find t in terms of z (cf Figure 6).

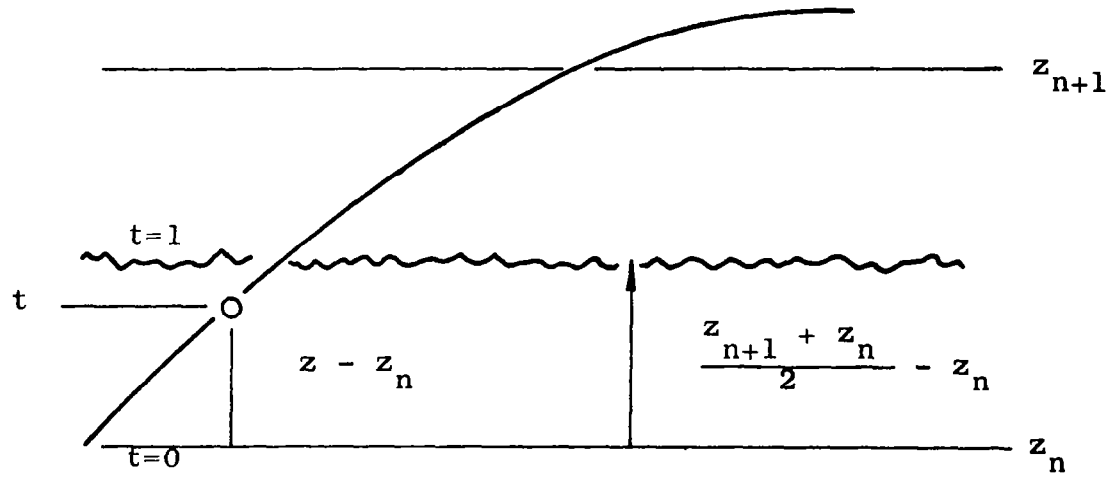

Figure 6

$$t = \frac{z - z_n}{\frac{z_{n+2} + z_n}{2} - z_n}$$

$$= 2\frac{z - z_n}{z_{n+1} - z_n} \quad . \tag{22}$$

Introducing equation (22) in (20)

$$v = A + \frac{2B(z-z_n)}{z_{n+1} - z_n} + \frac{4C(z-z_n)^2}{z_{n-1} - z_n)^2}$$

Expanding and collecting terms we get

$$v = \frac{4C}{(z_{n+1} - z_n)^2}\left\{z - \left[z_n - \frac{B(z_{n+1} - z_n)}{4C}\right]\right\}^2 + \left(A - \frac{B^2}{4C}\right) \quad . \tag{23}$$

Comparing equations (5) and (23), we obtain

$$A^* = A - B^2/4C \quad , \tag{24}$$

$$B^* = z_n - B(z_{n+1} - z_n)/4C \quad , \tag{25}$$

$$G^* = 4C/(z_{n+1} - z_n)^2 \quad . \tag{26}$$

Arithmetic statements 700-4 to -2 code equations (24-27) respectively:

```
AA(LC) = A1-(B1**2)/4.*C1)
ZZ(LC) = Z1-(B1*DZ/4.*C1)
GG(LC) =  4.*C1/(DZ**2)
```

But, for a quasi-linear sounding, equations (24) and (25) reduce to

$$A^* = A, \text{ and}$$

$$B^* = 0 ,$$

which are arithmetic statements 700 and 700+2 respectively, as well as 720 and 720 + 2. Consider then, the following reduction of equation (26) to linearity.

For $C = B^* = 0$, equation (2) becomes

$$x = A + By \text{ , or as before}$$

$$v = A + Bt \quad (0 \leq t \leq 1) , \tag{27}$$

as in Figure 7:

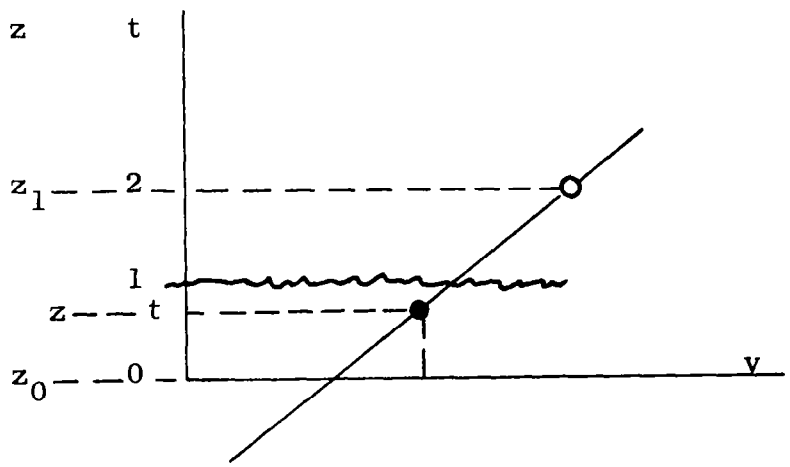

Figure 7

Putting t from equation (22) into equation (27), we get

$$v = A + 2B \frac{z - z_1}{z_2 - z_1} \quad , \tag{28}$$

$$v = \frac{2B}{z_2 - z_1} \quad , \quad \text{or}$$

$$B = v' \frac{z_2 - z_1}{2} \quad , \tag{29}$$

B1 = F1P

in which $v' = dv/dz$, coded as F1P in arithmetic expression 700-10:

F1P = (F2-FM)/Z2-ZM)

Substituting B from equation (29) into equation (28) we get

$$v = A + 2v' \frac{z_2 - z_1}{2} \frac{z - z_1}{z_2 - z_1} \quad ,$$

$$= A + v_1' (z - z_1) \quad . \tag{30}$$

Solving equation (18) for v' (1 = n) we get

$$v_n' = \frac{2B}{z_{n+2} - z_n} \tag{31}$$

So, substituting equation (31) in equation (30) we get

$$v = A + 2B \frac{(z - z_n)}{(z_{n+1} - z_n)} \quad .$$

Hence, finally

$$G^*_{linear} = \frac{2B}{z_{n+1} - z_n} \quad , \tag{32}$$

which is coded as arithmetic statements 700+1 and 720+1:

$$GG(LC) = 2 \cdot * B1/DZ$$

D. PARAMETERS AT HALF-LAYER BOUNDING LEVELS

Incidentally, except for the first, ground-based data-layer, these LC- subscripts or indexes in these arithmetic statements are the half-layer counters ($0 \le t \le 1$). On the other hand, the L's themselves count just the data levels. As a matter of fact, the LC's include also the intra-half-layer levels of local maxima in the v = c+u sounding. Figure 8 summarizes the level-counter relationships.

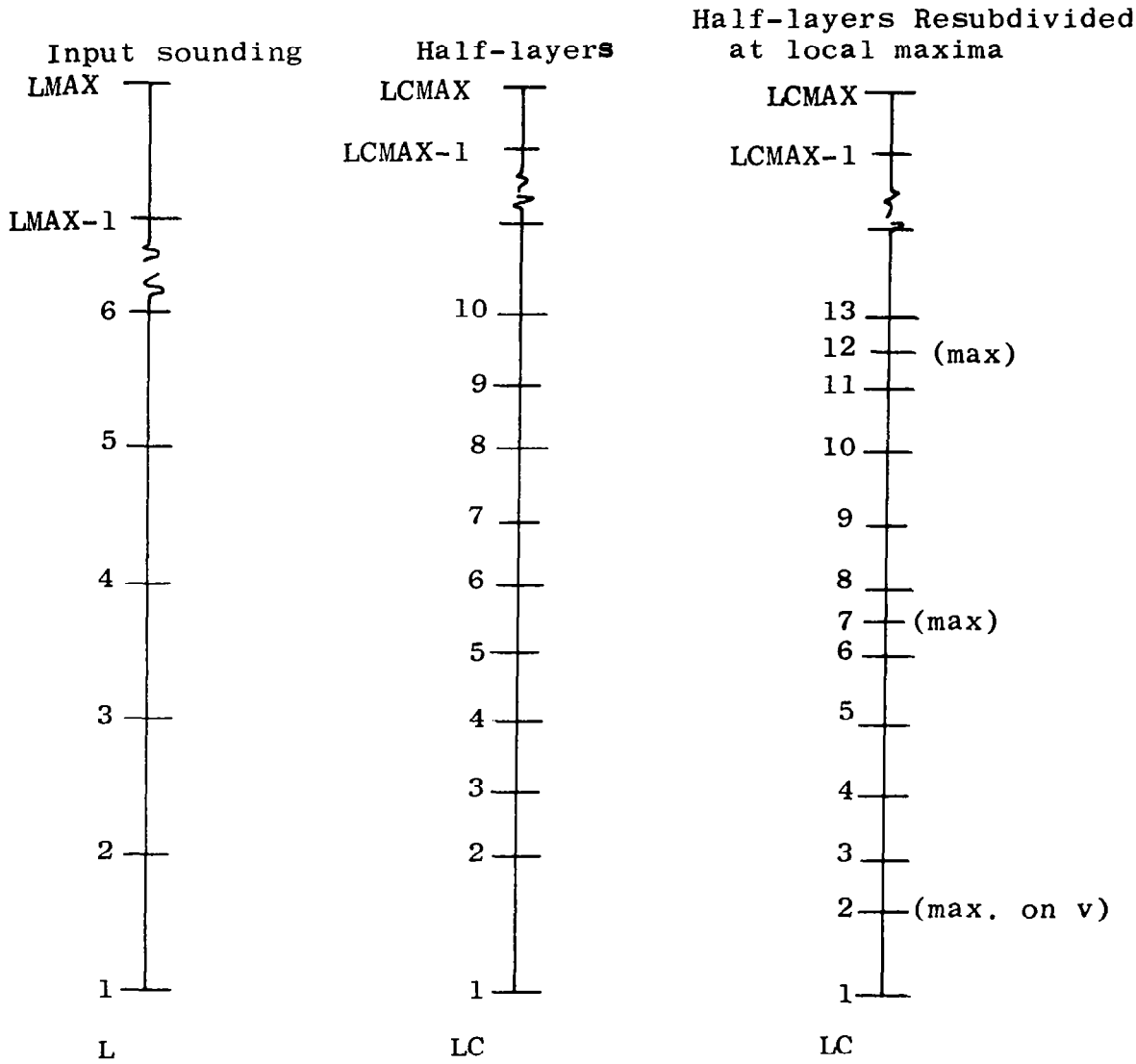

Figure 8

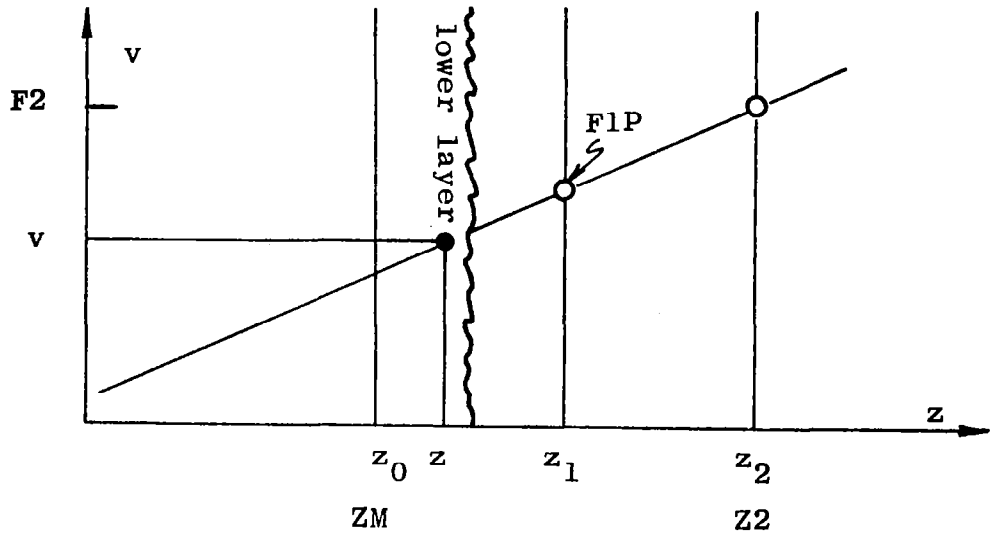

Figure 9

As seen in Figure 9 for example, the GG(LC) is the slope in the linear case (ZZ(LC) = 0.).

Now, consider the top-half layer.

The equations on page 113 of the referenced report evaluate the parabolic coefficients for the top-half layer:

$$A = \left[(v_n+v_{n+1}) - (v'_{n+1}-v'_n)(z_{n+1} - z_n)/4\right]/2 , \tag{33}$$

$$B = (v_{n+1} - v_n) - (v'_{n+1} + v'_n)\,(z_{n+1} - z_n)/4 , \tag{34}$$

$$C = - \left[(v_{n+1} - v_n) - (3v'_{n+1} + v'_n)(z_{n+1}-z_n)/4\right]2 . \tag{35}$$

Equations (33-35) are encoded as arithmetic statements 710+3 to 710+5 respectively:

```
A1 = (F1+F2 - (F2P - F1P) * DZ/4.)/2 .

B1 = DF - (F2P + F1P) * DZ/4 .

C1 = - (DF - (3 . * F2P + F1P) * DZ/4.)/2 .
```

(These new values are stored in the same location as those for equations (17-19).

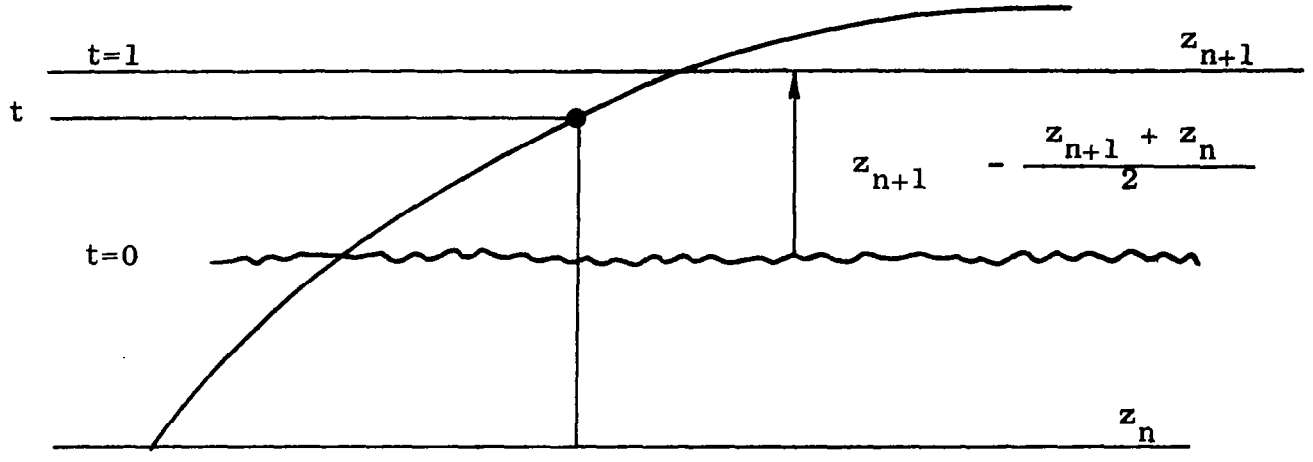

Figure 10

For the top-half layer (v. Figure 10),

$$t = \frac{2\left(z - \frac{z_{n+1} + z_n}{2}\right)}{z_{n+1} - z_n} \qquad (36)$$

Substituting t from equation (36) into equations 20 we get, after expanding and collecting terms

$$v = \frac{4C}{(z_{n+1}-z_n)^2}\left\{z - \left(\frac{(z_{n+1}+z_n)}{2} - \frac{B(z_{n+1}-z_n)}{4C}\right)\right\}^2 + A - \frac{B^2}{4C} \quad , \tag{34}$$

which is in the form

$$v = A^* + G^* (z - B^*)^2 \tag{5}$$

Comparing equations (5) and (37), we have

$$A^* = A - B^2/4C \quad , \tag{38}$$

$$B^* = \frac{z_{n+1} + z_n}{2} + \left(-\frac{B}{2C}\right)\left(\frac{z_{n+1} - z_n}{2}\right) , \tag{39}$$

$$G^* = \frac{4C}{(z_{n+1} - z_n)^2} \quad . \tag{40}$$

As before B^*, the vertex ordinate, is measured from sea-level.

The equations (38-40) are encoded as arithmetic statements 720-4 to 720-2 respectively:

```
AA(LC) = A1 - (B1**2)/(4.*C1)

ZZ(LC) = (Z2 + Z1)/2 - B1*DZ/(4.*C1)

GG(LC) = 4.*C1/(DZ**2)
```

Equations (33-35) and (38-40) give the parabolic coefficients and parameters at half-layer bounding levels. The sound-speed there is given by an equation similar in form to equation (33); viz

$$c = 1/2 \left[c_n+c_{n+1} - (c'_{n+1}-c'_n)(z_{n+1}-z_n)/4\right] , \qquad (41)$$

$$= \frac{c_n+c_{n+1}}{2} - 1/2\left[\frac{(c'_{n+1}-c'_n)}{2} \quad \frac{(z_{n+1}-z_n)}{2}\right] .$$

On the right, the first term is the mean sound-speed for a half layer, while the second term is that half-layer's increment in the speed of sound. The equation (41) is coded as arithmetic statement 730; vix

```
CC(LC) = (C(L)+C(LP)-((C(LP2)-C(L))/(ZP2-Z1)-(C(LP)-C(LM))/
         (Z2-ZM)) * DZ/4.)/2 .
```

For a top-half layer, for example, this statement would graphically as in Figure 12.

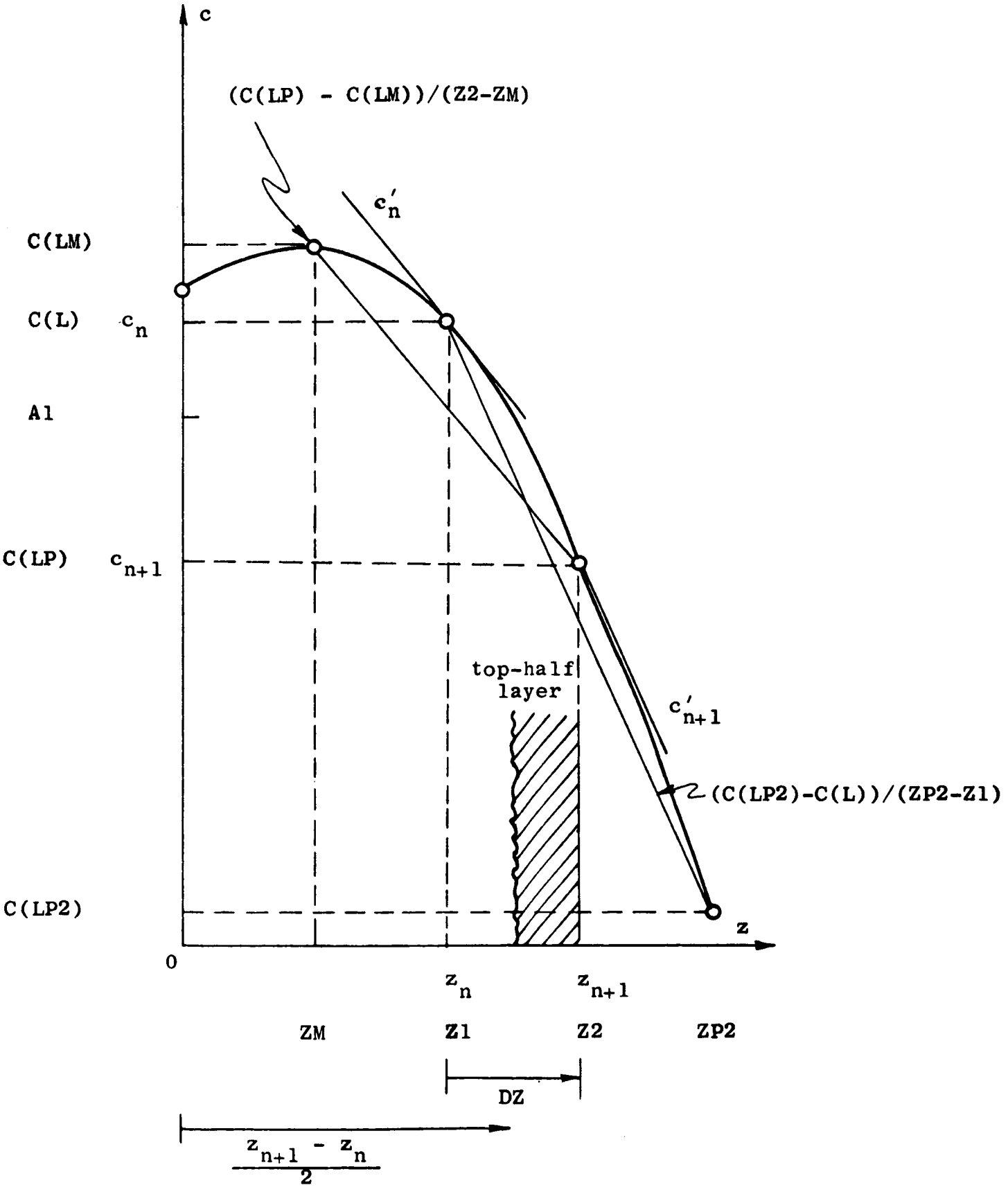
c
(C(LP) - C(LM))/(Z2-ZM)
c'n
C(LM)
C(L)
cn
A1
C(LP)
cn+1
top-half
layer
c'n+1
(C(LP2)-C(L))/(ZP2-Z1)
C(LP2)
z
0
zn
zn+1
ZM
Z1
Z2
ZP2
DZ
zn+1 - zn
2

Figure 11

E. INTEGRATION OF THE RAY EQUATION

So far, some of the main arithmetic statements in the mainline program have been discussed. Let us continue to identify the remaining statements before discussing the logical details of the program. The next series of statements concern the integration of the ray equation. This may be readily paired-off with the equations of the report.

Arithmetic statements 855-2 and 855+1 are height-functions of the integrand of the ray equation:

$$F(z) = \left[c^2+u(k-u)\right]/c\left[K+c-u\right]^{1/2} \quad , \tag{42}$$

as given on page 113 of the report.

Incidentally, for the convenience in following the coded program with the text of the reports, we recognize the use of multiple symbols for a given parameter. In statement 855-15, for example, GGGQRT is $\sqrt{G^*}$. Given by equation (26), this curvature variable G^* has also been represented as σ in the report; e.g., page 114.

At the zenith of a ray (where cos φ=1.), Snell's law gives

$$K = \frac{c_o}{\cos\ \varphi} + u_o = \frac{c}{\cos\ \varphi} + u = v \tag{43}$$

Introducing K from equation (43) into equation (5) for v and solving for y we get

$$y = z = B^* \pm \sqrt{\frac{K - A^*}{G^*}} \quad , \qquad \text{or}$$

$$= B^* \pm P \quad . \tag{44}$$

The statement 855-13 is this P (found also on page 114 of the report) where the K is coded as VTEST, Snell's constant along a ray, as evaluated by arithmetic statement 800-6. The A is the abscissa of the parabolic vertex, introduced by equation (7). The P- function is the vertical distance from the parabolic vertex to the topping-out of the ray for which P is computed.

F. RAY-RANGING AND DATA POINTS

In this evaluative comparison, it is necessary to preserve the derivative character of landing distance with respect to the initial ray inclination, especially around the data levels in the linear sounding ; e.g., Figure 12; which shows two different examples.

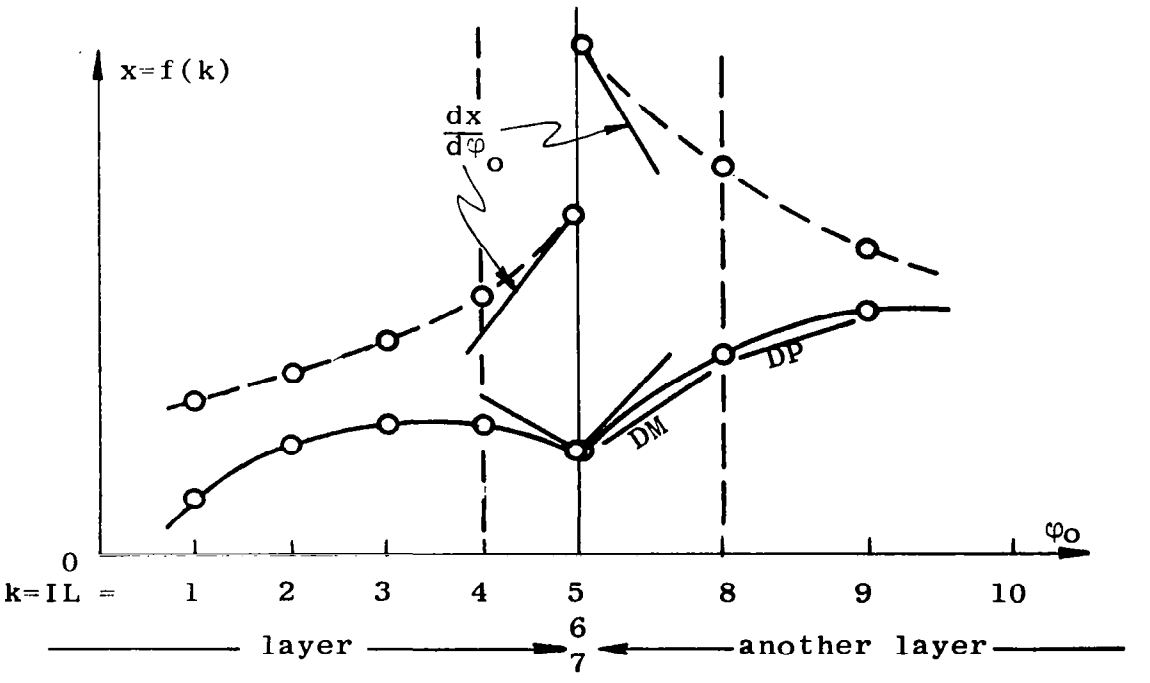

Figure 12

$$\ell_2'(\varphi) = \frac{\varphi - \varphi_1}{(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} + \frac{\varphi - \varphi_o}{(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} \quad , \qquad \text{in which}$$

$$\ell_2'(\varphi_1) = \frac{1}{\varphi_2 - \varphi_1} - \frac{1}{\varphi_2 - \varphi_o} \quad , \quad \text{etc.,}$$

It may easily be shown that

$$f'(\varphi_1) = f_o\left(\frac{1}{\varphi_2-\varphi_o} - \frac{1}{\varphi_1-\varphi_o}\right) + f_1\left(\frac{1}{\varphi_1-\varphi_o} - \frac{1}{\varphi_2-\varphi_1}\right) + f_2\left(\frac{1}{\varphi_2-\varphi_1} - \frac{1}{\varphi_2-\varphi_o}\right)$$

$$= \frac{f_1 - f_o}{\varphi_1 - \varphi_o} + \frac{f_o - f_2}{\varphi_2 - \varphi_o} + \frac{f_2 - f_1}{\varphi_2 - \varphi_1}$$

$$= \frac{f_1 - f_o}{\varphi_1 - \varphi_o} + \frac{f_2 - f_1}{\varphi_2 - \varphi_2} - \frac{f_2 - f_o}{\varphi_2 - \varphi_o}$$

$$f'(\varphi_1) = \frac{f_1 - f_o}{\varphi_1 - \varphi_o} + \frac{f_2 - f_1}{\varphi_2 - \varphi_1} - \frac{f_2 - f_o}{\varphi_2 - \varphi_o} \quad . \qquad (45)$$

Likewise

$$f'(\varphi_o) = \frac{f_1 - f_o}{\varphi_1 - \varphi_o} + \frac{f_2 - f_o}{\varphi_2 - \varphi_o} - \frac{f_2 - f_1}{\varphi_2 - \varphi_1} \quad , \qquad \text{and}$$

$$f'(\varphi_2) = -\frac{f_1 - f_o}{\varphi_1 - \varphi_o} + \frac{f_2 - f_1}{\varphi_2 - \varphi_1} + \frac{f_2 - f_o}{\varphi_2 - \varphi_o} \quad .$$

Taking equation (45), for example,

$$f'(\varphi_1) = DM + DP + \frac{f_o - f_1 + f_1 - f_2}{\varphi_2 - \varphi_o} \quad , \qquad \text{where}$$

code symbols from arithmetic statements 482 and 482+1 have been introduced. (Incidentally the DM & DP may be read as "Delta-Minus" and "Delta-Plus" - v. Figure 12 -- the slopes to the minus and plus sides of ICENT.) Continuing, we have

$$f'(\varphi_1) = DM + DP - \frac{DM(\varphi_1 - \varphi_o) + DP(\varphi_2 - \varphi_1)}{\varphi_2 - \varphi_o} ,$$

$$= DP\left(1 - \frac{\varphi_2 - \varphi_1}{\varphi_2 - \varphi_o}\right) + DM\left(1 - \frac{\varphi^1 - \varphi_o}{\varphi_2 - \varphi_o}\right) ,$$

$$= DP\ \frac{2\ \varphi_1 - \varphi_o - \varphi_1}{\varphi_2 - \varphi_o} - DM\ \frac{2\ \varphi_1 - \varphi_2 - \varphi_1}{\varphi_2 - \varphi_o} ; \quad \text{or}$$

generally

$$f'(\varphi_i) = DP\ \frac{2(\varphi_i) - \varphi_{i-1} - \varphi_i}{\varphi_{i+1} - \varphi_{i-1}} - DM\ \frac{2(\varphi_i) - \varphi_{i+1} - \varphi_i}{\varphi_{i+1} - \varphi_{i-1}} . \quad (i=0,1,2)$$

Designate the index k = 0, n to correspond with IM = 0, ICENT = 1 and IP = 2 (cf. Figures 12 & 13); viz., n = 2; allowing the triad to range over the whole material I = 2 to IMAX avoiding discontinuities in each ray's landing distance with its initial inclination likewise,

φ = PHI,

φ_k = PHI(IM), PHI(ICENT), PHI(IP),

x = X,

x_k = X(IM), X(ICENT), X(IP),

x = x(φ),

$x' = \frac{dx}{d\varphi}$.

From

$$x' = \sum_{k=0}^{n=2} \ell_k' \; x_k + R'_{n=2}(\varphi) \quad , \qquad \text{in which}$$

$$\ell_k' = \ell_k'(\varphi) = \sum_{\substack{j=0 \\ j\neq k}}^{n=2} \frac{\pi_n(\varphi)}{\left[\varphi - \varphi_k\right]\left[\varphi - \varphi_j\right]\left[\pi_n'(\varphi_k)\right]} \quad , \quad \text{and}$$

$$\pi_n(\varphi) = (\varphi-\varphi_o)\ldots(\varphi-\varphi_n) = (\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2) \quad ,$$

$$\pi_n'(\varphi_k) = (\varphi_k-\varphi_o)\ldots(\varphi_k-\varphi_{k-1})(\varphi_k-\varphi_{k+1})\ldots(\varphi_k-\varphi_n) \; ;$$

or in particular

$$\pi_2'(\varphi_o) = (\varphi_o - \varphi_1)(\varphi_o - \varphi_2) \; ,$$

$$\pi_2'(\varphi_1) = (\varphi_1 - \varphi_o)(\varphi_1 - \varphi_2) \; ,$$

$$\pi_2'(\varphi_2) = (\varphi_2 - \varphi_o)(\varphi_2 - \varphi_1) \; .$$

Thus,

$$\ell_o' = \sum_{\substack{j=0 \\ j\neq k}}^{n=2} \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_o)(\varphi-\varphi_j)(\varphi_o-\varphi_1)(\varphi_o-\varphi_2)} \quad ,$$

$$\ell_1' = \sum_{\substack{j=0 \\ j\neq k}}^{n=0} \frac{(\varphi-\varphi_o)(\varphi-\varphi_2)(\varphi-\varphi_2)}{(\varphi-\varphi_1)(\varphi-\varphi_j)(\varphi_1-\varphi_o)(\varphi_1-\varphi_2)} \quad ,$$

$$\ell_2' = \sum_{\substack{j=0 \\ j\neq k}}^{n=2} \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_2)(\varphi-\varphi_j)(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} \quad .$$

Expanding

$$\ell_o' = \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi_o-\varphi_1)(\varphi_o-\varphi_2)} + \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_o)(\varphi-\varphi_2)(\varphi_o-\varphi_1)(\varphi_o-\varphi_2)} \quad , \qquad (46)$$

$$\ell_1' = \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_1)(\varphi-\varphi_o)(\varphi_1-\varphi_o)(\varphi_1-\varphi_2)} + \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_1)(\varphi-\varphi_2)(\varphi_1-\varphi_o)(\varphi_1-\varphi_2)} \quad , \qquad (47)$$

$$\ell_2' = \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_2)(\varphi-\varphi_o)(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} + \frac{(\varphi-\varphi_o)(\varphi-\varphi_1)(\varphi-\varphi_2)}{(\varphi-\varphi_2)(\varphi-\varphi_1)(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} \quad . \qquad (48)$$

Simplifying,

$$\ell_o' = \frac{\varphi-\varphi_2}{(\varphi_o-\varphi_1)(\varphi_o-\varphi_2)} + \frac{\varphi-\varphi_1}{(\varphi_o-\varphi_1)(\varphi_o-\varphi_2)} \quad , \qquad (49)$$

$$\ell_2' = \frac{\varphi-\varphi_2}{(\varphi_1-\varphi_o)(\varphi_1-\varphi_2)} + \frac{\varphi-\varphi_o}{(\varphi_1-\varphi_o)(\varphi_1-\varphi_2)} \quad , \qquad (50)$$

$$\ell_2' = \frac{\varphi-\varphi_1}{(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} + \frac{\varphi-\varphi_o}{(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} \quad . \qquad (51)$$

Substituting φ_o, φ_1 and φ_2 in each of equations (49), (50) and (51), we get

$$\ell_o'(\varphi_o) = \frac{1}{\varphi_o - \varphi_1} + \frac{1}{\varphi_o - \varphi_2} \quad ,$$

$$l_o'(\varphi_1) = \frac{\varphi_1 - \varphi_2}{(\varphi_o-\varphi_1)(\varphi_o-\varphi_2)} = \frac{1}{\varphi_o - \varphi_1} - \frac{1}{\varphi_o - \varphi_2} ,$$

$$l_o'(\varphi_2) = \frac{\varphi_2 - \varphi_1}{(\varphi_o-\varphi_1)(\varphi_o-\varphi_2)} = \frac{1}{\varphi_o - \varphi_2} - \frac{1}{\varphi_o - \varphi_1} ,$$

$$l_1'(\varphi_o) = \frac{\varphi_o - \varphi_2}{(\varphi_1-\varphi_o)(\varphi_1-\varphi_2)} = \frac{1}{\varphi_1 - \varphi_o} - \frac{1}{\varphi_1 - \varphi_2} ,$$

$$l_1'(\varphi_1) = \frac{1}{\varphi_1 - \varphi_o} + \frac{1}{\varphi_1 - \varphi_2} ,$$

$$l_1'(\varphi_2) = \frac{\varphi_2 - \varphi_o}{(\varphi_1-\varphi_o)(\varphi_1-\varphi_2)} = \frac{1}{\varphi_1 - \varphi_2} - \frac{1}{\varphi_1 - \varphi_o} ,$$

$$l_2'(\varphi_o) = \frac{\varphi_o - \varphi_1}{(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} = \frac{1}{\varphi_2 - \varphi_o} - \frac{1}{\varphi_2 - \varphi_1} ,$$

$$l_2'(\varphi_1) = \frac{\varphi_1 - \varphi_o}{(\varphi_2-\varphi_o)(\varphi_2-\varphi_1)} = \frac{1}{\varphi_2 - \varphi_1} - \frac{1}{\varphi_2 - \varphi_o} ,$$

$$l_2'(\varphi_2) = \frac{1}{(\varphi_2 - \varphi_o)} + \frac{1}{\varphi_2 - \varphi_1} .$$

The x' - expression (p. 26),

$$x' = \sum_{k=0}^{n=2} l_k' \, x_k + R_{n=2}'(\varphi) ,$$

here expands as

$$x'(\varphi_o) = x_o \ell_o'(\varphi_o) + x_1 \ell_1'(\varphi_o) + x_2 \ell_2'(\varphi_o) \quad , \tag{52}$$

$$x'(\varphi_1) = x_o \ell_o'(\varphi_1) + x_1 \ell_1'(\varphi_1) + x_2 \ell_2'(\varphi_1) \quad , \tag{53}$$

$$x'(\varphi_2) = x_o \ell_o'(\varphi_2) + x_1 \ell_1'(\varphi_2) + x_2 \ell_2'(\varphi_2) \quad . \tag{54}$$

Substituting the last nine equations (52) to (53) in (54) we get,

$$x'(\varphi_o) = x_o\left(\frac{1}{\varphi_o-\varphi_1} + \frac{1}{\varphi_o-\varphi_2}\right) + x_1\left(\frac{1}{\varphi_1-\varphi_o} - \frac{1}{\varphi_1-\varphi_2}\right) + x_2\left(\frac{1}{\varphi_2-\varphi_o} - \frac{1}{\varphi_2-\varphi_1}\right) \quad ,$$

$$x'(\varphi_1) = x_o\left(\frac{1}{\varphi_o-\varphi_1} - \frac{1}{\varphi_o-\varphi_2}\right) + x_1\left(\frac{1}{\varphi_1-\varphi_o} + \frac{1}{\varphi_1-\varphi_2}\right) + x_2\left(\frac{1}{\varphi_2-\varphi_1} - \frac{1}{\varphi_2-\varphi_o}\right) \quad ,$$

$$x'(\varphi_2) = x_o\left(\frac{1}{\varphi_o-\varphi_2} - \frac{1}{\varphi_o-\varphi_1}\right) + x_1\left(\frac{1}{\varphi_1-\varphi_2} - \frac{1}{\varphi_1-\varphi_o}\right) + x_2\left(\frac{1}{\varphi_2-\varphi_o} + \frac{1}{\varphi_2-\varphi_1}\right) .$$

$$x'(\varphi_o) = \frac{x_o - x_1}{\varphi_o - \varphi_1} + \frac{x_o - x_2}{\varphi_o - \varphi_2} + \frac{x_1 - x_2}{\varphi_2 - \varphi_1} ,$$

$$x'(\varphi_1) = \frac{x_o - x_1}{\varphi_o - \varphi_1} + \frac{x_o - x_2}{\varphi_2 - \varphi_o} + \frac{x_1 - x_2}{\varphi_1 - \varphi_2} =$$

$$x'(\varphi_2) = \frac{x_o - x_2}{\varphi_o - \varphi_2} + \frac{x_o - x_1}{\varphi_1 - \varphi_o} + \frac{x_1 - x_2}{\varphi_1 - \varphi_2}$$

$$x'(\varphi_o) = \overset{DM}{\frac{x_1 - x_o}{\varphi_1 - \varphi_o}} + \frac{x_2 - x_o}{\varphi_2 - \varphi_o} - \overset{DP}{\frac{x_2 - x_1}{\varphi_2 - \varphi_1}}$$

$$x'(\varphi_1) = \overset{DM}{\frac{x_1 - x_o}{\varphi_1 - \varphi_o}} + \overset{DP}{\frac{x_2 - x_1}{\varphi_2 - \varphi_1}} - \frac{x_2 - x_o}{\varphi_o - \varphi_o}$$

$$x'(\varphi_2) = \frac{x_2 - x_o}{\varphi_2 - \varphi_o} + \overset{DP}{\frac{x_2 - x_1}{\varphi_2 - \varphi_1}} - \overset{DM}{\frac{x_1 - x_o}{\varphi_1 - \varphi_o}}$$

$$x'(\varphi_o) = DM - DP + \frac{x_2 - x_o}{\varphi_2 - \varphi_o} ,$$

$$x'(\varphi_1) = DM + DP - \frac{x_2 - x_o}{\varphi_2 - \varphi_o} ,$$

$$x'(\varphi_2) = -DM + DP + \frac{x_2 - x_o}{\varphi_2 - \varphi_o} .$$

Manipulate $\dfrac{x_2 - x_o}{\varphi_2 - \varphi_o}$:

$$= \frac{x_1 - x_o + x_2 - x_1}{\varphi_2 - \varphi_o} \quad .$$

$$x_1 - x_o = DM\ (\varphi_1 - \varphi_o) \quad ,$$

$$x_2 - x_1 = DP\ (\varphi_2 - \varphi_1) \quad .$$

$$\frac{x_2 - x_o}{\varphi_2 - \varphi_o} = \frac{DM\ (\varphi_1 - \varphi_o) + DP\ (\varphi_2 - \varphi_1)}{\varphi_2 - \varphi_o} \quad .$$

$$x'(\varphi_o) = DM - DP + \frac{DM\ (\varphi_1 - \varphi_o) + DP\ (\varphi_2 - \varphi_1)}{\varphi_2 - \varphi_o}$$

$$x'(\varphi_1) = DM + DP - \frac{DM\ (\varphi_1 - \varphi_o) + DP\ (\varphi_2 - \varphi_1)}{\varphi_2 - \varphi_o}$$

$$x'(\varphi_2) = -DM + DP + \frac{DM\ (\varphi_1 - \varphi_o) + DP\ (\varphi_2 - \varphi_1)}{\varphi_2 - \varphi_o}$$

$$x'(\varphi_o) = DP\left(-1 + \frac{\varphi_2 - \varphi_1}{\varphi_2 - \varphi_o}\right) + DM\left(1 + \frac{\varphi_1 - \varphi_o}{\varphi_2 - \varphi_o}\right)$$

$$= -DP\left(\frac{-\varphi_o - \varphi_1}{\varphi_2 - \varphi_o}\right) + DM\left(\frac{\varphi_2 - 2\varphi_o + \varphi_1}{(\varphi_2 - \varphi_o)}\right)$$

$$x'(\varphi_1) = DP\left(1 - \frac{\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right) + DM\left(1 - \frac{\varphi_1-\varphi_o}{\varphi_2-\varphi_o}\right)$$

$$= DP\left(\frac{\varphi_1-\varphi_o}{\varphi_2-\varphi_o}\right) + DM\left(\frac{\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right)$$

$$x'(\varphi_2) = DP\left(1 + \frac{\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right) + DM\left(-1 + \frac{\varphi_1-\varphi_o}{\varphi_2-\varphi_o}\right)$$

$$= DP\left(\frac{2\varphi_2-\varphi_o-\varphi_1}{\varphi_2-\varphi_o}\right) + DM\left(\frac{-\varphi_2+\varphi_1}{\varphi_2-\varphi_o}\right)$$

$$x'(\varphi_o) = -DP\left(\frac{\varphi_1-\varphi_o}{\varphi_2-\varphi_o}\right) + DM\left(\frac{\varphi_2-2\varphi_o-\varphi_2}{\varphi_2-\varphi_o}\right)$$

$$x'(\varphi_1) = +DP\left(\frac{\varphi_1-\varphi_o}{\varphi_2-\varphi_o}\right) + DM\left(\frac{\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right)$$

$$x'(\varphi_2) = +DP\left(\frac{2\varphi_2-\varphi_o-\varphi_1}{\varphi_2-\varphi_o}\right) - DM\left(\frac{\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right)$$

These equations can be generalized to

$$x'(\varphi_o) = +DP\left(\frac{2\varphi_o-\varphi_o-\varphi_1}{\varphi_2-\varphi_o}\right) - DM\left(\frac{2\varphi_o-\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right),$$

$$x'(\varphi_1) = DP\left(\frac{2\varphi_1-\varphi_o-\varphi_1}{\varphi_2-\varphi_o}\right) - DM\left(\frac{2\varphi_1-\varphi_2-\varphi_2}{\varphi_2-\varphi_o}\right),$$

$$x'(\varphi_2) = DP\left(\frac{2\varphi_2-\varphi_o-\varphi_1}{\varphi_2-\varphi_o}\right) - DM\left(\frac{2\varphi_2-\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right),$$

or

$$x'(\varphi_i) = DP\left(\frac{2\varphi_i-\varphi_o-\varphi_1}{\varphi_2-\varphi_o}\right) - DM\left(\frac{2\varphi_i-\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right)$$

Taking, for instance i=1 in this equation, we can transform to

$$x'(\varphi_1) = \frac{x_2-x_1}{\varphi_2-\varphi_1}\ \frac{\varphi_1-\varphi_o}{\varphi_2-\varphi_o} + \frac{x_1-x_o}{\varphi_1-\varphi_o}\ \frac{\varphi_2-\varphi_1}{\varphi_2-\varphi_o} ,$$

$$= \frac{(x_2-x_1)}{\varphi_2-\varphi_2}\left(\frac{\varphi_2-\varphi_o-\varphi_2+\varphi_1}{\varphi_2-\varphi_o}\right) + \frac{(x_1-x_o)}{\varphi_1-\varphi_o}\left(\frac{\varphi_2-\varphi_o-\varphi_1+\varphi_o}{\varphi_2-\varphi_o}\right) ,$$

$$= (x_2-x_1)\left(\frac{1}{\varphi_2-\varphi_1} - \frac{1}{\varphi_2-\varphi_o}\right) + (x_1-x_o)\left(\frac{1}{\varphi_1-\varphi_o} - \frac{1}{\varphi_2-\varphi_o}\right) ,$$

$$= \frac{x_1-x_o}{\varphi_1-\varphi_o} - \frac{(x_2-x_1)+(x_1-x_o)}{\varphi_2-\varphi_o} + \frac{x_2-x_1}{\varphi_2-\varphi_1} ,$$

$$= \frac{x_1-x_o}{\varphi_1-\varphi_o} - \frac{x_2-x_o}{\varphi_2-\varphi_1} + \frac{x_2-x_1}{\varphi_2-\varphi_1} .$$

And, likewise, taking also,

$$x'(\varphi_o) = \frac{x_2-x_1}{\varphi_2-\varphi_1}\ \frac{\varphi_o-\varphi_1}{\varphi_2-\varphi_o} - \frac{x_1-x_o}{\varphi_1-\varphi_o}\ \frac{2\varphi_o-\varphi_2-\varphi_1}{\varphi_2-\varphi_o}$$

$$= \frac{(x_2-x_1)}{\varphi_2-\varphi_1}\left(\frac{\varphi_2-\varphi_1-\varphi_2+\varphi_o}{\varphi_2-\varphi_o}\right) - \frac{(x_1-x_o)}{\varphi_1-\varphi_o}\left(\frac{-(\varphi_1-\varphi_o)-(\varphi_2-\varphi_o)}{\varphi_2-\varphi_o}\right)$$

$$= \frac{(x_2-x_1)}{\varphi_2-\varphi_1}\left(\frac{\varphi_2-\varphi_1-(\varphi_2-\varphi_o)}{\varphi_2-\varphi_o}\right) - (x_1-x_o)\left[\frac{-(\varphi_1-\varphi_o)}{(\varphi_1-\varphi_o)(\varphi_2-\varphi_o)} + \frac{-(\varphi_2-\varphi_o)}{(\varphi_1-\varphi_o)(\varphi_2-\varphi_o)}\right]$$

$$= (x_2-x_1)\left[\frac{\varphi_2-\varphi_1}{(\varphi_2-\varphi_1)(\varphi_2-\varphi_o)} - \frac{(\varphi_2-\varphi_o)}{(\varphi_2-\varphi_1)(\varphi_2-\varphi_o)}\right] + (x_1-x_o)\left(\frac{1}{\varphi_2-\varphi_o} + \frac{1}{(\varphi_1-\varphi_o)}\right)$$

$$= \frac{x_2-x_1}{\varphi_2-\varphi_o} - \frac{x_2-x_1}{\varphi_2-\varphi_1} + \frac{x_1-x_o}{\varphi_2-\varphi_o} + \frac{x_1-x_o}{\varphi_1-\varphi_o}$$

$$= \frac{x_1-x_o}{\varphi_1-\varphi_o} + \frac{x_2-x_1+x_1-x_o}{\varphi_2-\varphi_o} - \frac{x_2-x_1}{\varphi_2-\varphi_1}$$

$$= \frac{x_2-x_o}{\varphi_1-\varphi_o} + \frac{x_2-x_o}{\varphi_2-\varphi_o} - \frac{x_2-x_1}{\varphi_2-\varphi_1}$$

Finally, likewise, taking also

$$x'(\varphi_2) = \frac{x_2-x_1}{\varphi_2-\varphi_1}\left(\frac{2\varphi_2-\varphi_o-\varphi_1}{\varphi_2-\varphi_o}\right) - \frac{x_1-x_o}{\varphi_1-\varphi_o}\left(\frac{\varphi_2-\varphi_1}{\varphi_2-\varphi_o}\right)$$

$$= \frac{x_2-x_1}{\varphi_2-\varphi_1}\left(\frac{\varphi_2-\varphi_1+\varphi_2-\varphi_o}{\varphi_2-\varphi_o}\right) - \frac{x_1-x_o}{\varphi_1-\varphi_o}\left(\frac{\varphi_2-\varphi_o-(\varphi_1-\varphi_o)}{\varphi_2-\varphi_o}\right)$$

$$= (x_2-x_1)\left[\frac{\varphi_2-\varphi_1}{(\varphi_2-\varphi_1)(\varphi_2-\varphi_o)} + \frac{\varphi_2-\varphi_o}{(\varphi_2-\varphi_1)(\varphi_2-\varphi_o)}\right] - (x_1-x_o)$$

$$\left[\frac{(\varphi_2-\varphi_o)}{(\varphi_1-\varphi_o)(\varphi_2-\varphi_o} - \frac{(\varphi_1-\varphi_o)}{(\varphi_1-\varphi_o)(\varphi_2-\varphi_o}\right]$$

$$= \frac{x_2-x_1+(x_1-x_o)}{\varphi_2-\varphi_o} + \frac{x_2-x_1}{\varphi_2-\varphi_1} - \frac{x_1-x_o}{\varphi_1-\varphi_o}$$

$$x'(\varphi_2) = -\frac{x_1-x_o}{\varphi_1-\varphi_o} + \frac{x_2-x_o}{\varphi_2-\varphi_o} + \frac{x_2-x_1}{\varphi_2-\varphi_1}$$

Likewise, for i=0 and i=2. Generally,

$$x'(\varphi_i) = \frac{x_i - x_{i-1}}{\varphi_i - \varphi_{i-1}} - \frac{x_{i+1} - x_{i-1}}{\varphi_{i+1} - \varphi_{i-1}} + \frac{x_{i+1} - x_i}{\varphi_{i+1} - \varphi_i}$$

Thus, for j or ICENT = i, i + 1 and i - 1,

$$x'(\varphi_j) = A \frac{x_j - x_{j-1}}{\varphi_j - \varphi_{j-1}} + B \frac{x_{j+1} - x_{j-1}}{\varphi_{j+1} - \varphi_{j-1}} + C \frac{x_{j+1} - x_j}{\varphi_{j+1} - \varphi_j} ,$$

with A, B and C = $\pm$1, as follows: For j = i, A = 1, B = -1 and C = 1; for ICENT = i-1 j = i-1, A = -1, B = 1 and C = 1; and for ICENT = i+1 j = i+1, A = 1, B = 1 and C = -1.

This equation codes up as

DXDPHI(I) = A*DM+B*DC + C*DP, (arithmetic statement 490-3) where

DC = (X(IP)-X(IM))/(PHI(IP-PHI(IM)) -- arithmetic statement 490-4.

G. PROPER LOCATION OF A POSSIBLE FOCUS FROM THE DATA TRIAD FIRST ABOVE A LOCAL SOUNDING-MAXIMUM

Consider next the ray-fan (1) that has penetrated an atmospheric layer topped out at a local sounding-maximum and that (2) has also zenithed out on a ray-returning layer somewhere above that maximum. The bottom ray of this fan, of course, range infinitely. (For convenience, this infinite distance has been tabbed with the value of 1000. km.)

Consider in particular the possibility that the second ray may range farther than the first one (from the infinitely ranging

bottom-ray). In this case, the aforementioned analytics (Subsection F) for locating foci cannot properly apply. Instead, the following considerations should be used.

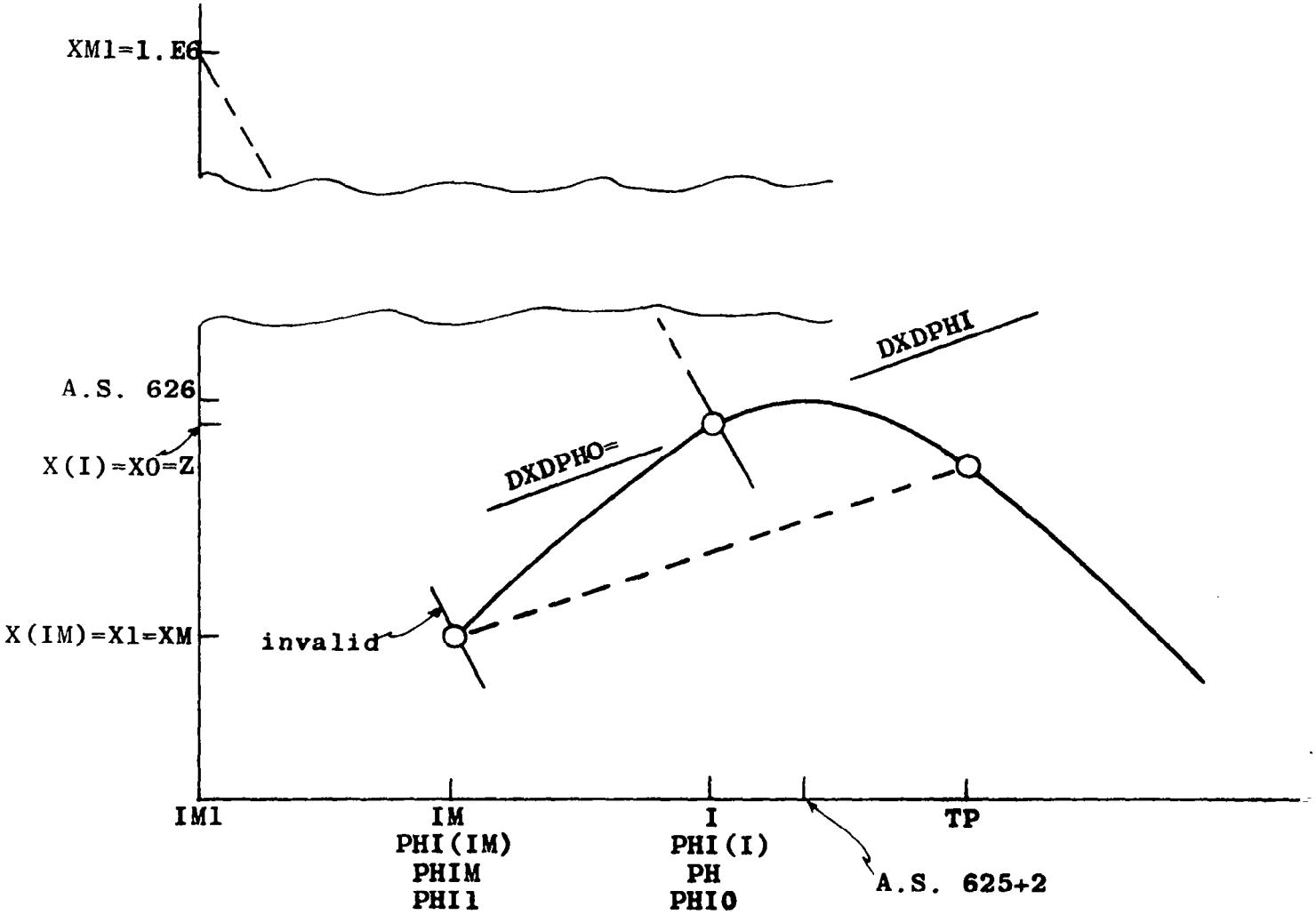

FIGURE 14

As in Figure 14 (wherein notations are expressed in coded form), XM1, XM, and Z are the ranging distances of the bottom, first, and second rays, having initial inclinations of PHI(IM1), PHI(IM) and PHI(I), respectively. And, DXDPHO = DXDPHI designates the derivative of the $r(\varphi_o)$-function at I, the second ray. DXDPHIM, at IM.

Then, the following geometry accommodates the possibility that Z is greater than XM, attending the invalid use of a DXDPHO = DXDPHIM based on the infinitely ranging XM1. (Such a procedure is the one set forth in the previous subsection.) In this subsection, this procedure is to be replaced by a quadratic interpolation involving the three data-points centered on I, the second above a local sounding-maximum point; i.e., centered on the second ray above the bottom one (of the fan), having infinite range.

Following with our notation,

$x = a + b\,(\varphi - \varphi_o) + c\,(\varphi - \varphi_o)^2$, which for $\varphi = \varphi_o$ becomes

$$(x)_o = a \quad , \tag{55}$$

$$\left(\frac{dx}{d\varphi}\right)_o = b \quad , \tag{56}$$

$$c = \frac{x_1 - x_o - \left(\frac{dx}{d\varphi}\right)_o (\varphi_1 - \varphi_o)}{(\varphi_1 - \varphi_o)^2} \quad , \tag{57}$$

$$\frac{dx}{d\varphi} = b + 2c\,(\varphi - \varphi_o) \quad ,$$

$$\varphi_* = \varphi_o - \frac{b}{2c} \quad , \qquad (5$$

$$x_* = a + b\left(\frac{-b}{2c}\right) + c\left(\frac{b^2}{4c^2}\right) \quad , \quad .$$

$$x_* = a - \frac{b^2}{4c} \quad . \qquad (5$$

In SUBROUTINE TENSITY, then, equations (55) and (56) code into arithmetic statement 623. Equation (57) codes up as A. S. 625+1:

```
D = (X1 - X0 - DXDPHO*DPH)/DPHS
```

Equation (58) goes into A.S. 625+2:

```
PHIO = PHIO - DXDPHO/(2.*D)
```

Equation (59) is converted into A. S. 626:

```
XF = X0 - (DXDPHO**2)/(4.*D)
```

H. INTENSITY AT A FOCUS

At those angles φ_o, at which $dr/d\varphi_o = 0$, the individual focusing factors become infinitely large. The resulting intensity becomes therefore infinite at the landing point of the rays so inclined. This result is more dramatic than factual and is brought about by the failure of the basic assumption that, at such landing points, the relative rate of change of ray tube area per wavelength must no longer be considered as being negligible.

So, the analysis to determining the intensity at the foci must be redone to account for interference effects. Following L. M. Brekhovskikh (1956, pp. 483ff), the appropriate expression for the focusing factor becomes

$$f = (1.25/\tan\varphi_o)\left[2\pi r\sin\varphi_o/\lambda(d^2r/d\varphi_o^2)\right]^{\frac{2}{3}} .$$

which codes into arithmetic statement 630+1:

```
AA = 1.254*XF*SINF(PHIO)**0.33333/(TANF(PHIO)*DXDPHI2**0.66667)
```

With these foregoing computational relations explained, it is now felt that Program Sound, which is listed in the next Chapter, may be read without difficulty. A generous number of comment statements have been especially introduced into this listing, with the intention in mind to make it readable to one encountering this program for the first time. Therefore, no special discussion has been prepared to accompany the program listed in Chapter II, other than that given in this chapter.

CHAPTER II

PROGRAM OF SOUND INTENSITY ESTIMATES

ERRATA

NASA CR-61187
KN 67-698-1
COMPARISON OF TWO METHODS FOR
ESTIMATING SOUND INTENSITY

By

C. Eugene Buell
ROBERT C. BUNOGAMD
January 1968

Title Page: Author's name omitted from page. Is correct as indicated on the attached Title Page.

```
J 1.4          DATE 28AUG67       AT  091904
      PROGRAM SOUND
C     COMPARISON OF RAY TRACE METHODS
      COMMON /A/ LMAX, WDIR(50), WSPD(50), UEW(50), UNS(50), AZ(10),
     1 U(50), T(50), C(50), V(50), PHITOP(20), JM    , DPHIMIN, KMIN,
     2 KMAX, DPHI(440), IRAY(120), IMAX, PHI(440), Y(50), X(440),
     3 H(440), DXDPHI(440), F(440),TINS(440),IFOCUS,TINF(30),XFOCUS(30),
     4 XPOCUS(30), P, Q, R, IDAY(4), AA(120), ZZ(120), GG(120), CC(120),
     5 VV(120), YY(120), AAA(120), GGG(120), ZZZ(120), CCC(120),
     6 VVV(120), YYY(120), LCMAX, UUU(120), PHITOPC(40), JMC, KMINC,
     7 KMAXC, DPHIC(440), IRAYC(120), IMAXC, PHIC(440), XC(440),
     8 HC(440), DXDPHIC(440), FC(440), TINSC(440), IFOCUSC, TINFC(30),
     9 XFOCUSC(30), XPOCUSC(30),PC,QC, RC, TTT(120), PHIP(30),PHIPC(30),
     1 DELV(120), DELDV(120), VL(120), VU(120), DVL(120), DVU(120),
     2 FT(440), FTC(440), NAME(30), NAMEC(30)
      EQUIVALENCE (LMAX,LCMAX), (WDIR(1),U(1)), (UEW(1),C(1)), (UNS(1),
     1 V(1)), (JM,JMC), (DPHI(1),DPHIC(1)),
     2 (IRAY(1),IRAYC(1)), (IMAX,IMAXC), (PHI(1),PHIC(1)), (X(1),XC(1)),
     3 (H(1),HC(1)), (DXDPHI(1),DXDPHIC(1)), (F(1),FC(1)), (TINS(1),
     4 TINSC(1)), (IFOCUS,IFOCUSC), (TINF(1),TINFC(1)), (XFOCUS(1),
     5 XFOCUSC(1)), (XPOCUS(1), XPOCUSC(1)), (PHIP(1),PHIPC(1)),
     6 (DELV(1),VU(1)), (DELDV(1),DVU(1)), (FT(1),FTC(1)),
     7 (NAME(1),NAMEC(1))
      TYPE INTEGER Q, QC, R, RC, P, PC
C     SET UP TEST-ROUTINE ALTERNATIVE FOR THE PARABOLIC MODEL
      READ (60, 1) NTEST
    1 FORMAT (I1)
C     SET UP CONTROL ON THE POSSIBLE INPUT-ERRORS.
      LLL = 0
   10 CALLSINPUT (IE)
      IF (IE - 0) 6, 7, 8
    8 STOP
    6 LLL = 1
      PRINT 9
    9 FORMAT (*0 ERROR IN SINPUT*)
      GO TO 10
    7 IF (LLL .EQ. 1) GO TO 10
C     SET UP ORIGINAL SOUNDING.
      DO 40 I = 1, LMAX
      ANG = 0.0174533*(270. - WDIR(I))
      UEW(I) =              WSPD(I)*COSF(ANG)
   40 UNS(I) =              WSPD(I)*SINF(ANG)
C     ORIENT ON ASSIGNED AZIMUTH
      AZ =AZ/57.29578
      DO 50 I = 1,LMAX $ VELS = 20.0468
      U(I) = UEW(I)*SINF(AZ) + UNS(I)*COSF(AZ)
      C(I) = VELS*SQRTF(          T(I))
   50 V(I) = C(I) + U(I)
      IF (NTEST) 60,699
C     LINEAR LAYER MODEL
C     DETERMINE THE PHI INCREMENTS, NUMBER OF REFRACTING LAYERS,  RAYS/
C    1 REFRACTED IN EACH LAYER, AND TOTAL NUMBER OF RAYS
   60 CALL ADJUST(C,U,V,LMAX,DPHIMIN,KMIN,KMAX,PHITOP,JM,DPHI,IRAY,IMAX)
C     FIND RAYS AND THEIR LANDING DISTANCE, TURNING LEVEL AND
C    1 INCLINATION FOR LINEAR MODEL
      IF(JM.EQ.0) GO TO 10
      IL = 0 $ PHIZ = 0.0
```

```
1.4            DATE 28AUG67        AT  091904
      C      OVER ALL REFLECTING LAYERS
             DO 340 J1 = 1,JM
             IM = IRAY(J1)
      C      FOR EVERY RETURNED RAY IN EACH LAYER
             DO 330 I1 = 1,IM
             CI = COSF(PHIZ)
             VTEST = (C/CI) + U
             IL = IL + 1
             PHI(IL) = PHIZ
             IF(I1.EQ.IM) GO TO 330
      C      LOCATE LAYER WHERE RAY TOPS
             DO 230 K1 = 1,LMAX
             IF (VTEST.GT.(V(K1) + 1.E-5)) 230,210
        210  IF (VTEST .GT. (V(K1) - 1.E-5)) 220, 250
        220  IF (I1 .NE. 1) GO TO 240
        230  CONTINUE
      C      RAY TOPS OUT EXACTLY AT LAYER K1
        240  K = 2
             GO TO 260
      C      RAY TOPS OUT BETWEEN K1 - 1 AND K1
        250  K = 1
        260  K2 = K1 - 1
      C      FIND CURVATURE AND DISTANCE FOR EACH RAY
             XM = 0.
             DO300K1 = 1,K2
             I = K1
             J = K1 + 1
             COSI = C(1)*CI/(C - (U(I) - U)*CI)
             IF (COSI .GT. 1. ) COSI= 1.
             IF (K1 .EQ. K2                ) GO TO 270
             COSJ = C(J)*CI/(C - (U(J) - U)*CI)
             IF (COSJ .GT.1.)270,280
        270  COSJ = 1.
        280  COSM = .5*(COSI + COSJ)
             CM = 0.5*(C(1) + C(J))
             PSII = C(1)*SQRTF(1. - COSI**2)/(C(I)*COSI + U(I))
             PSIJ = C(J)*SQRTF(1. - COSJ**2)/(C(J)*COSJ + U(J))
             PSII = SINF(ATANF(PSII))
             PSIJ = SINF(ATANF(PSIJ))
             RR = ((C(J)-C(I))*COSM + U(J) - U(I))/(CM*(Y(J)-Y(I)))
             ABSR = ABSF(RR)
             IF (ABSR .LT. 1.E-5) GO TO 290
             XM = XM + ABSF((PSIJ - PSII)/RR)
             GO TO 300
        290  XM = XM + (Y(J) - Y(I))*SQRTF(1.-PSII**2)/PSII
        300  CONTINUE
             X(IL) = 2.*XM
             IMM = IM - 1
             IF (I1 .EQ. IMM) GO TO 320
             GO TO (310,320), K
        310  H(IL) = (Y(K2) + (Y(K1)-Y(K2))*(VTEST-V(K2))/(V(K1)-V(K2)))/1000.
             GO TO 330
        320  H(IL) = Y(K1)/1000.
        330  PHIZ = PHIZ + DPHI(IL)
             X(IL) = H(IL) = 0.
        340  CONTINUE
```

```
1 1.4           DATE 28AUG67        AT  091904
      P = 8HABLE
      CALL TENSITY (IMAX,X,PHI,DXDPHI,F,TINS,IFOCUS,TINF,XFOCUS,PHIP,FT,
     1 P,NAME)
      Q = 8HSTRAIGHT
      R = 8H-STEPPED
      CALL PRINT (P,Q,R,AZ,IDAY,         Y,      LMAX,T,C,U,V,X,H,JM,
     1 PHI, IMAX, F, TINS, IFOCUS, TINF, XFOCUS, PHIP,FT, NAME)
C     PARABOLIC LAYER MODEL
C     ADJUSTS LAYERS AND GETS PARABOLA PARAMETERS
C     FIRST LAYER, TWO POINTS AND ONE TANGENT PARABOLA
  699 F1 = V(1)
      F2 = V(2)
      Z1 = Y(1)
      Z2 = Y(2)
      F2P = (V(3)-V(1))/(Y(3)-Y(1))
      DZ = Z2 - Z1
      FS = (F2-F1)/DZ
      C1 = (F2P-FS)/DZ
      B1 = FS*2.*Z2/DZ - F2P*(Z1+Z2)/DZ
      A1 = F1 + (Z2*F2P-FS*(2*Z2-Z1))*Z1/DZ
      AA(1) = A1 - (B1**2)/(4*C1)
      GG(1) = C1
      ZZ(1) = -B1/(2.*C1)
      VV(1) = V(1) $ YY(1) = Y(1)
      CC (1) = C(1)
      LM2 = LMAX - 2
      LC = 1
      DO 740 L = 2,LM2
      LP = L + 1 $ LP2 = L + 2 $ LM = L -1
      F1 = V(L)
      F2 = V(LP)
      Z1 = Y(L)
      Z2 = Y(LP)
      FM = V(LM)
      ZM = Y(LM)
      FP2 = V(LP2)
      ZP2 = Y(LP2)
      DZ = Z2 - Z1
      DF = F2 - F1
      F1P = (F2 - FM)/(Z2-ZM)
      F2P = (FP2-F1)/(ZP2-Z1)
C     BOTTOM HALFLAYER
      A1 = F1
      B1 = F1P*DZ/2.
      C1 = (DF-(F2P+3.*F1P)*DZ/4.)/2. $ LC = LC + 1
      IF(ABSF(C1/B1).LT.1.E-3) GO TO 700
      AA(LC) = A1 - (B1**2)/(4.*C1)
      ZZ(LC) = Z1 - B1*DZ/(4.*C1)
      GG(LC) = 4.*C1/(DZ**2)
      GO TO 710
  700 AA(LC) = A1
      GG(LC) = 2.*B1/DZ
      ZZ(LC) = 0.
C     THIS ZZ(LC) VALUE FLAGS LINEAR FORM A + G(Z-Z0), Z0 = VALUE AT
C    1 BOTTOM
  710 CC(LC) = C(L)
```

```
1 1.4          DATE 28AUG67       AT  091904
            YY(LC) = Y(L)
            VV(LC) = V(L)
      C     TOP HALF LAYER
            A1 = (F1+F2-(F2P-F1P)*DZ/4.)/2.
            B1 = DF - (F2P + F1P)*DZ/4.
            C1 = -(DF-(3.*F2P+F1P)*DZ/4.)/2.
            LC  = LC + 1
            IF(ABSF(C1/B1).LT.1.E-3) GO TO 720
            AA(LC) = A1 - (B1**2)/(4.*C1)
            ZZ(LC) = (Z2+Z1)/2 - B1*DZ/(4.*C1)
            GG(LC) = 4.*C1/(DZ**2)
            GO TO 730
        720 AA(LC) = A1
            GG(LC) = 2.*B1/DZ
            ZZ(LC) = 0.
        730 CC(LC) = (C(L)+C(LP)-((C(LP2)-C(L))/(ZP2-Z1)-(C(LP)-C(LM))
           1 /(Z2-ZM))*DZ/4.)/2.
            YY(LC) = (Z2+Z1)/2.
        740 VV(LC) = A1
            LCMAX = LC
      C     CHECKS FOR MAX WITHIN HALF LAYERS AND RESUBDIVIDES
            LC = 0
            LM = LCMAX - 1
            DO 770 L = 1, LM
            LC = LC + 1
            AAA(LC) = AA(L)
            ZZZ(LC) = ZZ(L)
            GGG(LC) = GG(L)
            CCC(LC) = CC(L)
            YYY(LC) = YY(L)
            VVV(LC) = VV(L)
            LP = L + 1
            Y1 = YY(L)
            Y2 = YY(LP)
            Y3 = ZZ(L)
            IF (Y3.EQ.Y1) GO TO 770
      C     MAX/MIN/LINEARITY DOES NOT FALL AT BOTTOM OF LAYERS
            IF (Y3.GT.Y1.AND.Y3.LT.Y2) 750, 770
      C     MAX/MIN WITHIN LAYERS
        750 IF (GG(L).GT.0.) 770, 760
      C     SUBDIVIDES ON MAX WITHIN LAYERS
        760 LC = LC + 1
            AAA(LC) = AA(L)
            ZZZ(LC) = ZZ(L)
            GGG(LC) = GG(L)
            CCC(LC) = CC(L) + (CC(LP)-CC(L))*(ZZ(L)-YY(L))/(YY(LP)-YY(L))
            YYY(LC) = ZZ(L)
            VVV(LC) = AA(L)
        770 CONTINUE
            LCMAX = LC
            IF (NTEST) GO TO 776
            DO 773, LC = 1, 120
            DELV(LC) = 0.
        773 DELDV(LC) = 0.
            DO 775, LC = 2, LCMAX
            LCM = LC - 1
```

```
1 1.4          DATE 28AUG67       AT  091904
      VL(LC) = AAA(LCM) + (GGG(LCM))*(YYY(LC)-ZZZ(LCM))**2
      VU(LC) = AAA(LC) + (GGG(LC))*(YYY(LC)-ZZZ(LC))**2
      DVL(LC) = 2.*(GGG(LCM))*(YYY(LC)-ZZZ(LCM))
      DVU(LC) = 2.*(GGG(LC))*(YYY(LC)-ZZZ(LC))
      DELV(LC) = VU(LC) - VL(LC)
      DELDV(LC) = DVU(LC) - DVL(LC)
C     ONLY FOR SPECIAL ERROR-ANALYSIS IN LOOP 775, USE NEXT THREE CARDS.
      PRINT 774, LC, AAA(LC), GGG(LC), YYY(LC), ZZZ(LC), VL(LC), VU(LC),
     1 DVL(LC), DVU(LC), DELV(LC), DELDV(LC)
  774 FORMAT (*0 TEST*, I10, F10.5, E10.3, F10.3, 7(F10.5))
  775 CONTINUE
      DELV(1) = 0.
      DELDV(1) = 0.
      PC = 6HRAYO
      GC = 6HPARABOLI
      CALL PRINT1 (PC,GC, A2, IDAY, YYY, LCMAX, DELV, DELDV, AAA,
     1 ZZZ, GGG)
      IF (NTEST) 776, 1041
  776 CONTINUE
      UUU(1) = U(1)
      VELS = 20.0468
      DO 780 I = 2, LCMAX
      TTT(I) = ((CCC(I))/(VELS))**2
  780 UUU(I) = VVV(I) - CCC(I)
      TTT(1) = T(1)
      CALL ADJUST (C, U, VVV, LCMAX, DPHIMIN, KMINC, KMAXC, PHITOPC,
     1 JMC, DPHIC, IRAYC, IMAXC)
C     FIND RAYS AND THEIR LANDING DISTANCE, TURNING LEVEL AND
C     1 INCLINATION FOR PARABOLIC MODEL
      IL = 0
      PHIZ = 0.0
C     LOOP OVER ALL REFLECTING LAYERS
      DO 1040 J1 = 1, JMC
      IM = IRAYC(J1)
C     LOOP FOR EVERY RETURNED RAY IN EACH REFLECTING LAYER
      DO 1030 I1 = 1, IM
      PHID = PHIZ*57.29578
C     INITIAL RAY ANGLE, RAY COUNTER, ETC.
      CI = COSF(PHIZ)
      VTEST = C/CI + 0
      IL = IL + 1
      PHIC(IL) = PHIZ
      IF(I1.EQ.IM) GO TO 1030
C     TEST FOR RAY EXACTLY ON LAYER TOP (K = 2) OR NOT (K = 1)
      DO 820 K1= 1, LCMAX
      IF (VTEST.GT.(VVV(K1)+1.E-5)) 820,800
  800 IF (VTEST.GT.(VVV(K1)-1.E-5)) 810,840
  810 IF (I1.NE.1) GO TO 830
  820 CONTINUE
  830 K = 2
      GO TO 845
  840 K = 1
  845 K2= K1 - 1
      IF (XM .EQ. 5.E5 .AND. I1 .EQ. 1) GO TO 850
      XM = 0.
      K3 = 1
```

```
1.4          DATE 28AUG67       AT  091904
      GO TO 851
C     INDEX DELIMITING THE 1000-LOOP TO JUST FINDING THE HEIGHT CORRESPONDING TO
C      THE VTEST-VALUE OF THAT INFINITELY TRAVELING RAY (VIZ., THE PHIBOT RAY
C      OF THE NEXT MORE ELEVATED FAN AND REFRACTING LAYER NOW TO BE CONSIDERED)
C      WHICH TOPS OUT AT A LOCAL MAX IN THE SOUND-PROPAGATION SOUNDING.
  850 K3 = K2
C     LOOP TO COMPUTE CURVATURE AND DISTANCE FOR EACH RAY
  851 DO 1000 K1 =K3, K2
C     K2 REFERENCES THE LEVEL AT WHICH THE PHIBOT-RAY (I1=1) OF A FAY-FAN TOPS
C      OUT (K=1), OR THE BOTTOM OF THE LAYER IN WHICH THE FANS INTERNAL-RAYS (I1
C      .GT.1 TO I1.LT.IM-1) TOP OUT (K=1), OR AT THE TOP OF WHICH THE PHITOP-RAY
C      (I1=IM-1) TOPS OUT (K=2), EXCEPT IF NOT ONLY I1=1 (AND HENCE K=1) BUT
C      ALSO ITS TOP IS THE ONE AS RECOGNIZED BY THE 820-LOOP AS BEING ABOVE A
C      LOCAL MAX (IN WHICH EXCEPTION THE RAY TOPS OUT AT THE LEVEL OF THAT MAX).
C      INCIDENTALLY, BOTH BOUNDING LEVELS OF THIS LAYER ARE ADJACENT LC-LEVELS
C      (VIZ., EITHER PARABOLIC JOIN-POINTS AT ONE OF THE DATA LEVELS AND A MID-
C      LEVEL BETWEEN THEM OR ONE SUCH JOIN-POINT AND AN LC-SUBDIVISION ON A
C      LOCAL MAX, OVER WHICH ONE PARABOLIC ARC IS CONTINUOUS).  WHEREAS AN INFI-
C      NITELY RANGING PHITOP-RAY ASYMPTOTES OUT ALWAYS AT THE TOP OF THE FIRST
C      SUCH LAYER SUPERJACENT TO K2, AT EXTENDED RANGE THE I1-RAY ASYMPTOTICALLY
C      APPROACHES AS ITS ZENITH A LOCAL-MAX LEVEL WHICH IS (OFTEN WELL) BELOW
C      THE ASSOCIATED K2-LEVEL.  BUT, FOR SUCH AN I1-RAY, THE LEVEL TO BE SPECI-
C      FIED AND SOUGHT SHALL NEVERTHELESS BE THAT CORRESPONDING TO ITS VTEST-
C      VALUE, CONTAINED IN THE LAYER MENTIONED, SINCE ITS ZENITH IS OTHERWISE
C      SPECIFIED BY THE HEIGHT-COORDINATE OF THE LOCAL MAX.
      I = K1
      GGGI = GGG(I)
      GGGSRT =SQRTF(ABSF(GGGI))
      AAAI = AAA(I)
      P1= SQRTF(ABSF((VTEST-AAAI)/GGGI))
      ZZZI = ZZZ(I)
C     SHUNT FOR INFINITELY RANGING PHIBOT-RAY, TO FIND HEIGHT CORRESPONDING TO
C      ITS ASSOCIATED VTEST VALUE.
      IF (XM .EQ. 5.E5 .AND. I1 .EQ. 1) GO TO 960
C     ROUND-OFF OF REAL-VARIABLE P-FUNCTION TO FIXED ZERO FOR INFINITELY RANGING
C      PHITOP-RAY.
C     ROUND-OFF NOW AUTHORIZED SINCE LARGEST ROUND P1 AT LOCAL MAX .LE. 2.77E-2
      J = I + 1
      YYYJ = YYY(J)
      IF (P1 .LT. 3.E-2 .AND. GGGI .LT. 0.) GO TO 884
      YYYI = YYY(I)
      A1 = ABSF((YYYI-ZZZI)/P1)
      C2 = CCC(J)
      C1 = CCC(I)
      V1 = VVV(I)
      F1 = (C1**2 + (V1-C1)*(VTEST-V1+C1))/(C1*SQRTF(VTEST+2.*C1-V1))
      IF(K1.NE.K2) 855, 960
C     K1  NOT UP TO THE REFERENCE SURFACE FOR WHICH THE RAY TOPS OUT IN
C      THE NEXT SUPERJACENT LAYER OR AT ITS BOUNDARIES, SO RAY PENETRATES THE
C      LAYER WHOSE LOWER BOUNDARY IS K1.
  855 V2 = VVV(J)
      F2 = (C2**2 + (V2-C2)*(VTEST-V2+C2))/(C2*SQRTF(VTEST+2.*C2-V2))
      K2M = K2 - 1
      IF (K1 .EQ. K2M .AND. I1 .EQ. 1) 856, 857
  856 FMEAN = (2.*F2+F1)/3.
  857 FMEAN = (F2 + F1)/2.
```

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1 1.4           DATE 28AUG67        AT  091904
          A2 = ABSF((YYYJ-ZZZ1)/P1)
          IF (ZZZI          )          860, 910
     C    REMAINS PARABOLIC
   860 IF (GGGI .LT. 0.) GO TO 880
     C    COMPUTE TRAVEL DISTANCE OF RAY PENETRATING A LAYER SUPERJACENT TO
     C     THE MINIMUM OF THE FITTED PARABOLIC SOUNDING-SEGMENT FOR THAT LAYER.
          IF (VTEST .LT. AAAI) GO TO 870
     C    (NEXT STATEMENT NOW TRIVIAL.)
          IF (A2 .GT. 1.) A2 = 1.
          IF (A1 .LE. 1.) GO TO 867
     C    865-BYPASS NOW AUTHORIZED, SINCE LARGEST FOUND A1 .LE. 1 + 2.6E-6
          GO TO 866
     C    PP = ABSF(ZZZI - YYYI)
     C    PRINT 865, PHID     , K1, K2, A1, ZZZI, YYYI, PP,P1,VTEST,AAAI,GGGI
     C865 FORMAT (*0 IMPOSSIBLE TEST*, F10.3, 2(I3), F10.7, 6(F10.3), E10.3)
   866 A11 = 1. + 3.E-6
          IF (A1 .GT. A11) GO TO 872
          IF (A1 .GT. 1.) A1 = 1.
   867 ADD = FMEAN*ABSF(ASINF(A2) - ASINF(A1))/GGGQRT
          GO TO 950
   870 IF (VTEST .LE. AAA1) GO TO 900
     C    COMPUTE TRAVEL DISTANCE OF RAY PENETRATING A LAYER SUBJACENT TO
     C     1 A MAX IN SOUNDING AND TOPPING OUT ABOVE THAT MAX.
          ADD = FMEAN*ABSF(LOGF((A2+SQRTF(1.+A2**2))/(A1+SQRTF(1.+A1**2))))
         1 /GGGQRT
          GO TO 950
     C    COMPUTE TRAVEL DISTANCE OF RAY PENETRATING A LAYER SUBJACENT TO
     C     1 A MAX IN SOUNDING AND TOPPING OUT BELOW THAT MAX OR AT IT IF K1=K2 (FOR
     C      WHICH A2=1.), BUT ABOVE IT IF K1 .NE. K2 .
   900 IF (A2 .LT. 1.) A2 = 1.
          IF (A1 .GE. 1.) GO TO 908
     C    ADJUSTMENT FOR ROUND-OFF.
     C    THE 905-BYPASS NOW AUTHORIZED, SINCE SMALLEST FOUND A1 .GT. 1. - 1.E-7
          GO TO 906
     C    PP = ABSF(ZZZI - YYYI)
     C    A13 = 1. - 1.E-5
     C    IF (A1 .GT. A13) GO TO 907
     C    PRINT 905, PHID, K1, K2, A1, ZZZI, YYYI, PP, P1, VTEST, AAAI, GGGI
     C905 FORMAT (*0 SUB-MAX TEST*, F10.3, 2(I3), 8(E10.3))
   906 A12 = 1. -1.E-5
          IF (A1 .LT. A12 .AND. A1 .NE. 0.) GO TO 874
   907 IF (A1 .LT. 1.) A1 = 1.
   908 ADD = FMEAN*ABSF(LOGF((A2+SQRTF(A2**2-1.))/(A1+SQRTF
         1 (A1**2-1.))))/GGGQRT
          GO TO 950
     C    ERROR INSERTIONS FROM IMPOSSIBLE TESTS
   870 XM = 0. $ YTOP = 1.E5 $ GO TO 1005
   872 XM = 0. $ YTOP = 2.E5
          PRINT 873, A1
   873 FORMAT (*0 200-TEST*, F10.7)
          GO TO 1005
   874 XM = 0. $ YTOP = 3.E5 $ GO TO 1005
   876 XM = 0. $ YTOP = 4.E5 $ GO TO 1005
   878 XM = 0. $ YTOP = 5.E5 $ GO TO 1005
   882 XM = 0. $ YTOP = 6.E5 $ GO TO 1005
     C    INITIAL PHIBOT-RAY OF A REFRACTING LAYER HAS ITS ZENITH ON A SOUNDING MAX
```

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1 1.4            DATE 28AUG67        AT  091904
      864 XM = 5.E5 $ GO TO 1005
C         LINEAR LAYER CASE
      910 IF (VTEST .LT. AAAI) GO TO 876
C         CONSIDER SLOPE OF LINEAR SOUNDING
          IF (GGGI .LT. -1.E-8) GO TO 920
          IF (GGGI .GT. 1.E-8) GO TO 930
          GO TO 940
C         COMPUTE TRAVEL DISTANCE OF RAY PENETRATING LINEAR LAYER
      920 ADD =2.*(SQRTF(ABSF((VTEST-AAAI)))/(-GGGI))*FMEAN*(SQRTF(1.+Q)-1.)
          GO TO 950
      930 IF(Q .GT. 1.) Q = 1.
          ADD = 2.*(SQRTF(ABSF((VTEST-AAAI)))/GGGI)*FMEAN*(1.-SQRTF(1. - Q))
          GO TO 950
      940 ADD = FMEAN*(YYYJ-YYYI)/(SQRTF(ABSF(VTEST-AAAI)))
      950 ADD = ABSF(ADD)
          XM = XM + ADD
          GO TO 1000
C         COMPUTE PARAMETERS OF RAY AND LAYER IN WHICH RAY TOPS OUT
      960 IF (ZZZI.EQ.0.) GO TO 990
C         SOUNDING IN LAYER IS PARABOLIC
          IF (VTEST .GE. AAAI .AND. GGGI .GT. 0.) GO TO 963
          IF (VTEST .LT. AAAI .AND. GGGI .LT. 0.) GO TO 964
          DIFF = ABSF(VTEST - AAAI)
C         961-BYPASS AUTHORIZED.
          GO TO 962
C         PRINT 961, PHID, DIFF, VTEST, AAAI,GGGI
C 961 FORMAT (*0 IMPOSSIBLE TEST*, F 10.3, 4(E10.3))
C         ROUND-OFF ADJUSTMENT.
      962 IF (DIFF .LT. 1.E-6) GO TO 963
          GO TO 878
C         FIND RAY ZENITH
      963 YTOP = ZZZI + P1
          IF (XM .NE. 5.E5) 980, 1005
      964 YTOP = ZZZI - P1
          IF (XM .NE. 5.E5) 980, 1005
C         EVALUATE SOUNDING AT RAY TOP
      980 V2 = VTEST
          A2 = 1.
          GO TO 992
C         SOUNDING IN LAYER IS LINEAR
      990 YTOP = YYYI + (VTEST-AAAI)/GGGI
          Q= 1.
      992 C2 = C1 + (C2-C1)*(YTOP-YYYI)/(YYYJ-YYYI)
C         FIND F-FUNCTION OF RAY FOR ITS TOPPING LAYER, LINEAR OR PARABOLIC
          F2 = V2/SQRTF(2*C2)
          FMEAN = (2.*F2+F1)/3.
          IF(ZZZI) 860, 910
     1000 CONTINUE
          IF (XM .EQ. 5.E5 .OR. J1 .EQ. 1.) GO TO 1005
          ILM2 = IL - 2
          XM2 = (XC(ILM2))/2.
          IF (I1 .GT. 1) GO TO 1005
          DELX = ABSF(XM - XM2)
          IF (DELX .LE. 2.6   ) XM = XM2
     1005 XC(IL) = 2.*XM
          GO TO (1010, 1020), K
```

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1 1.4           DATE 28AUG67        AT  091904
      1010 HC(IL)= YTOP/1000.
           GO TO 1030
      1020 HC(IL) = YYYJ/1000.
      1030 PHIZ = PHIZ + DPHIC(IL)
           XC(IL) = HC(IL) = 0.0
      1040 CONTINUE
           PC = 8HBRAVO
           CALL TENSITY (IMAXC, XC, PHIC, DXDPHIC, FC, TINSC, IFOCUSC,
          1 TINFC, XFOCUSC, PHIPC, FTC, PC, NAMEC)
           QC = 8HPARABOLI
           RC = 8HC-SMOOTH
           CALL PRINT (PC, QC, RC, AZ, IDAY,     YYY,      LCMAX,TTT,CCC,UUU,
          1 VVV, XC, HC, JSC, PHIC, IMAXC,FC, TINSC, IFOCUSC, TINFC, XFOCUSC,
          2 PHIPC, FTC, NAMEC)
           GO TO 10
      1041 CONTINUE
           END
```

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1.4          DATE 28AUG67       AT  091904
      SUBROUTINE ADJUST (C,U,V,LMAX,DPHIMIN,KMIN,KMAX,PHITOP,JM,DPHI,
     1 IRAY,IMAX)
      DIMENSION C(120),U(120),V(120),PHITOP(40),DPHI(440),IRAY(120)
C     DETERMINES THE NUMBER OF REFRACTING LAYERS, IF ANY, AND THENCE THE
C     1 NUMBER OF PHI INCREMENTS, THEIR SIZE, NUMBER OF RAYS IN EACH
C     2 LAYER AND TOTAL NUMBER OF RAYS
      VR = V(1)
      J = 0
C     FIND NUMBER OF REFRACTING LAYERS
      DO 80 I = 2, LMAX
      IF (V(I).GT.VR) 70,80
   70 J = J + 1
      VR = V(I)
      PHITOP(J) = ACOSF(C/(V(I)-U))
   80 CONTINUE
      JM = J
      IF (JM.EQ.0) GO TO 180
      PHIBOT = 0.
      I = 0
C     DETERMINE THE NUMBER OF PHI INCREMENTS IN EACH REFRACTING LAYER
      DO170 J = 1, JM
      K = ((PHITOP(J)-PHIBOT)/DPHIMIN)
      IF (K.LT.KMIN) 90, 100
   90 IM = KMIN
      GO TO 130
  100 IF (K.GT.KMAX) 110, 120
  110 IM = KMAX
      GO TO 130
  120 IM = K
  130 AA = IM
C     DETERMINE PHI INCREMENT IN EACH REFRACTING LAYER
      R = (PHITOP(J) - PHIBOT)/AA
C     FLAG AND ACCOUNT FOR RAY BIFURCATION AT TOP OF EACH
      IM2 = IM - 1 $ IM = IM + 2
      DO 160 I1 = 1, IM
      I = I +1
      IF (I1.LE.IM2) 140, 150
  140 DPHI(I) = R
      GO TO 160
  150 DPHI(I) = 0.
  160 CONTINUE
      IRAY(J) = IM
  170 PHIBOT = PHITOP(J)
      IMAX = I
  180 RETURN
      END
```

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1.4          DATE 28AUG67       AT  091904
      SUBROUTINE TENSITY (IMAX,X,PHI,DXDPHI,F,TINS,IFOCUS,TINF,XFOCUS,
     1 PHIP, FT, P, NAME)
      DIMENSION X(440), PHI(440), DXDPHI(440), F(440), TINS(440),
     1 IFOCUS(30), TINF(30), XFOCUS(30), XPOCUS(30), PHIP(30), FT(440),
     2 NAME(30)
      TYPE INTEGER P
C     CALCULATION OF THE FOCUS FACTOR FOR EACH OF THE IMAX RAYS RETURNED
      IN = IMAX - 1
      DO 490 I = 1, IMAX
  405 IF (X(I)) 420, 410
  410 DXDPHI(I) = F(I) = 0.0
      GO TO 490
C     FOR LINEAR MODEL ONLY (P .NE. BRAVO), SEARCH OUT AND AVOID DISCONTINUITIES
C      IN VARIATION OF EACH RAYS LANDING DISTANCE WITH ITS INITIAL INCLINATION.
  420 IF (I .EQ. 1) GO TO 475
      ICENT = I  $  A = 1.  $  B = -1.  $  C = 1.
C     SINCE X(IMAX)=0, I+1 HERE .LE. IMAX BECAUSE OF A.S. 405.
  430 IF (X(I+1)*X(I-1)) 480, 440
  440 IF (I .EQ. 2) GO TO 455
C     THE I-RAY IS EITHER PHIBOT OR PHITOP.
      IF (X(I-2)*X(I-1)) 450, 460
C     THE I-RAY IS PHITOP
  450 IF (P .NE. 8HBRAVO   ) GO TO 453
      IF (X(1) .EQ. 1.E6) GO TO 410
      IF (I .EQ. IN ) GO TO 453
      IP = ICENT + 3
      GO TO 481
  453 ICENT = I - 1  $  A = -1.  $  B = 1.
      GO TO 480
C     X(I-1) = X(1) = 0..  HENCE,-
  455 F(1) = 1.
C     THE I-RAY IS PHIBOT, EXCEPT IF I=2  .
C     THE L.S., IF (I .EQ. 3) GO TO 455, IS NOT NEEDED HERE, BECAUSE FOR  I=3
C      A.S. 430 BYPASSES TO 480.
  460 IF (X(I+1)*X(I+2)) 470, 410
  470 IF (P .NE. 8HBRAVO   .OR. I .EQ. 2) GO TO 475
      IF (X(I) .NE. 1.E6) GO TO 474
      DXDPHI(I) = -0.0  $  F(I) = 0.0  $  GO TO 490
C     THE L.S., IF (I .LE. 3) GO TO 490, IS NOT NECESSARY HERE, SINCE KMINC=5
C      AND KMIN=10 IN SUBROUTINE-ADJUST (A.S. 90), I. E. I HERE MUST BE .GE. 6 .
  474 IM = ICENT - 3  $  IP = ICENT + 1
      GO TO 482
  475 ICENT = I + 1  $  A = 1.  $  B = 1.  $  C = -1.
  480 IP = ICENT + 1
  481 IM = ICENT - 1
  482 DP = (X(IP)-X(ICENT))/(PHI(IP)-PHI(ICENT))
      DM = (X(ICENT)-X(IM))/(PHI(ICENT)-PHI(IM))
      DC = (X(IP)-X(IM))/(PHI(IP)-PHI(IM))
      AA = A*DM + B*DC + C*DP
      DXDPHI(I) = AA
      F(I) = X(1)/(ABSF(AA)*TANF(PHI(I)))
  490 CONTINUE
C     EXTRAPOLATION OF FOCUS FACTOR FOR FIRST AND LEAST INCLINED RAY
C     1 RETURNED
      IF(X(1)) 500, 520
C     PERFORM A LINEAR EXTRAPOLATION
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1 1.4            DATE 28AUG67       AT  091904
      C 500 F(1) = F(2) + (F(3)-F(2))*(X(1)-X(2))/(X(3)-X(2))
      C     PERFORM A QUADRATIC EXTRAPOLATION(A 500-ALTERNATIVE).
        500 F(1)=F(3)+(X(1)-X(3))*((((F(2)-F(3))/(X(2)-X(3)))*(X(4)-X(3))
           1 -(((F(4)-F(3))/(X(4)-X(3)))*(X(2)-X(3)))/(X(4)-X(2))+(((F(4)-F(3))
           2 /(X(4)-X(3))-(((F(2)-F(3))/(X(2)-X(3))))/(X(4)-X(2)))*(X(1)-X(3)))
            IF (F(1) .LE. 0.) 505, 520
        505 F(1) = 0.   $  DXDPHI(1) = 0.
        520 CONTINUE
      C     INTENSITY CALCULATIONS AT LANDINGS OF RAYS (I. E., AT RANGES OF X(I))
      C      HAVING UNIFORMLY INCREMENTED INCLINATIONS
      C     THE I IS A COUNTER OF LANDING POINTS, UP TO IMAX IN NUMBER
            DZERO = 204.
            DO 613 I = 1,IMAX
            FTOTAL = 0.
            IF (                        X(I).LT.1.E-1 .OR. X(I) .EQ. 1.E6) GO TO 600
            XII = X(I)
            FTOTAL = F(I)
      C     FIND TOTAL FOCUS FACTOR OF RAYS RETURNED TO EACH LANDING
      C     THE INNER 580-LOOP COMPARES THE RANGING OF RAYS BETWEEN EVERY I-POINT AND
      C      EVERY JP-LANDING-POINT.
            IN = IMAX - 1
            DO 580 J = 1, IN
            JP = J + 1
      C     AVOIDS THE BOUNDARIES OF THE REFRACTING LAYERS
        550 IF(X(J)*X(JP)) 560, 580
        560 IF((X(J)-XII)*(XII-X(JP)).GT.0.) 570, 580
      C     CASE I -   J .GT.  I.  BETWEEN XII AND X(JP) THE RAY-RANGE TRENDS EITHER
      C      FIRST INWARD TOWARD THE SOUND-SOURCE BUT THEN BACK OUTWARD PAST XII, IF
      C      X(JP) IS GREATER THAN XII, OR ELSE OUTWARD FROM XII AND THEN INWARD AND
      C      AGAIN PAST XII ON TOWARD THE SOURCE, IF THE JP-RAY LANDS CLOSER TO THE
      C      SOURCE THAN DOES I-RAY. CASE II -   JP .LT.  I. BETWEEN X(J) AND XII THE
      C      RAY-RANGE TRENDS EITHER FIRST OUTWARD PAST XII BUT THEN BACK TO XII (IF
      C      X(J) IS LESS THAN XII), OR ELSE INWARD TOWARD THE SOURCE BUT THEN BACK
      C      OUT TO XII (IF THE LANDING DISTANCE OF I-RAY IS CLOSER TO THE SOURCE THAN
      C      THAT OF J-RAY). - BUT, A 570-BYPASS TO 580 INDICATES THAT THE RAYS ARE
      C      CONTINUING REGULARLY TO GET EITHER AWAY FROM XII OR CONTINUING TO RANGE
      C      CLOSER TO XII.
        570 FTOTAL = FTOTAL + F(J) + (F(JP)-F(J))*(XII-X(J))/(X(JP)-X(J))
        580 CONTINUE
            IF(FTOTAL.GT.0.) 590, 600
        590 TINS(I) = DZERO -18.320 + 4.3429*LOGF(FTOTAL/(XII**2))
            GO TO 610
        600 TINS(I) = 0.0
        610 FI(I) = FTOTAL
            IF (X(I)) 613, 612
        612 IF (I .NE. 1) GO TO 613
            FI(1) = 1.
        613 CONTINUE
      C     LOCATE FOCI AND COMPUTE INTENSITY THERE
            IFOCUS = 0
            IN = IMAX - 1
            IN1 = IMAX - 2
            IF(DXDPHI(1).NE.0.) GO TO 614
            SIGB = SIGNF(1.,DXDPHI(2))
            GO TO 615
        614 SIGB = SIGNF(1.,DXDPHI(1))
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1.4          DATE 28AUG67        AT  091904
     C       FIND NUMBER OF FOCI
   615 DO 632 I = 2,IN
       IM = I - 1  $  IP = I + 1 $ XM = X(IM)  $  Z = X(I)  $  XP = X(IP)
       DXDPHIM = DXDPHI(IM) $ DXDPH  = DXDPHI(I)  $  DXDPHIP = DXDPHI(IP)
       PHIM = PHI(IM)  $  PH  = PHI(I)  $  PHIPP = PHI(IP)
       SIG = SIGNF(1.,DXDPH )
     C     FOR AN INFINITELY RANGING PHIBOT-RAY,A 631-BYPASS HERE (INSTEAD OF TO 632)
     C      MAKES SIGB NEGATIVE (BECAUSE OF A.S. 470+2).  HENCE THIS RAY WILL NOT BE
     C      CONSIDERED AS A MAX-FOCUS THE NEXT TIME THROUGH THE 632 DO-LOOP.
       IF (Z     .EQ. 1.E6) GO TO 631
       IF (Z       .EQ. 0.) GO TO 632
     C     RAY HAS FINITE RANGE.
       IF(SIG.EQ.SIGB) GO TO 632
       IF (P .EQ. 8HBRAVO   ) GO TO 616
     C     LINEAR MODEL BYPASS TO DISREGARD POSSIBLE FALSE FOCUS AT EACH DATA LEVEL.
       IF (XM .EQ. 0.                  .OR. XP .EQ. 0.) GO TO 631
   616 IFOCUS = IFOCUS + 1
     C     FIND DISTANCE TO A FOCUS.
     C     IN THE PARABOLIC CASE, FOR I=2 TO HAVE GOTTEN TO HERE, XM .NE. 0. AND
     C      HENCE THE I=2 BYPASSES TO 621..
       IF (XM .NE.0.) GO TO 621
     C     IN THE PARABOLIC CASE, XM=0 CONSIDERS POSSIBILITY THAT FOCUS FALLS BETWEEN
     C      PHIBOT I-RAY AND THE NEXT-BUT-LAST RAY OF PRECEEDING (NEXT LOWER) FAN OF
     C      RAYS. HENCE, FOR (2ND-ORDER) INTERPOLATING THIS FOCAL DISTANCE (BY A.S.
     C      626), THE LAST PREVIOUS AVAILABLE RAY WITH DIFFERENT LANDING DISTANCE AND
     C      VARIATION (DXDPHI) IS THE ONE BEFORE THE PHITOP-RAY OF PREVIOUS RAY-FAN.
     C     THE L.S., IF (I .LE. 3) GO TO     , IS NOT NECESSARY HERE, SINCE KMINC=5
     C      AND KMIN=10 IN SUBROUTINE-ADJUST (A.S. 90), I. E. I HERE MUST BE .GE. 6 .
       IM2 = I-3 $ XM2 = X(IM2) $ PHIM2 = PHI(IM2) $ DXDPHIM2=DXDPHI(IM2)
       XM = XM2  $  PHIM = PHIM2  $  DXDPHIM = DXDPHIM2
     C     IN VICINITY OF A FOCUS BETWEEN ADJACENT RAYS, SO COVARY RANGE AND INCLINA-
     C      TION THAT THEY HAVE THE BEST 2ND-ORDER FIT NEAREST THE RAY HAVING THE MOR
     C      EXTREME RANGE, WHETHER THE LONGEST OR SHORTEST.
   621 IF (SIGB .GT. 0.) GO TO 622
     C     CONSIDERS THE POSSIBILITY Z.GT.XM ATTENDING THE INVALID USE OF A DXDPH0=
     C      DXDPHIM BASED ON XM1.EQ.1.E6, A CONDITION TO BE REPLACED BY A QUADRATIC
     C      INTERPOLATION INVOLVING THE 3 DATA-POINTS CENTERED ON I, THE 2ND ABOVE A
     C      LOCAL SOUNDING-MAX POINT (2ND RAY ABOVE PHIBOT HAVING INFINITE RANGE).
       IM1 = I - 2  $  XM1 = X(IM1)
       IF (XM1 .EQ. 1.E6) GO TO 623
       IF (Z .LT. XM) 623, 624
   622 IF (Z .LT. XM) GO TO 624
   623 X0 = Z    $  DXDPH0 = DXDPH     $  PHI0 = PH
       X1 = XM                         $  PHI1 = PHIM $  GO TO 625
   624 X0 = XM  $  DXDPH0 = DXDPHIM  $  PHI0 = PHIM
       X1 = Z                          $  PHI1 = PH
   625 DPH = PHI1 - PHI0  $  DPHS = DPH**2
       D = (X1 - X0 - DXDPH0*DPH)/DPHS
       PHI0 = PHI0 - DXDPH0/(2.*D)
       PHIP(IFOCUS) = PHI0*57.29578
   626 XFOCUS(IFOCUS) = XF = X0 - (DXDPH0**2)/(4.*D)
       XFOCUS(IFOCUS) = XFOCUS(IFOCUS)/1000.
       DXDPHI2 = (DXDPH - DXDPHIM)/(PH - PHIM)
       IF (DXDPHI2) 627, 628, 629
   627 NAME(IFOCUS) = 3HMAX   $  GO TO 630
   628 NAME(IFOCUS) = 3HOUT  $  GO TO 630
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1 1.4            DATE 28AUG67        AT  091904
      629 NAME(IFOCUS) = 3HMIN
C     CALCULATE FOCUSING FACTOR
      630 DXDPHI2 = ABSF(DXDPHI2)
          AA = 1.254*XF*SINF(PHIO)**0.33333/(TANF(PHIO)*DXDPHI2**0.66667)
          TINF(IFOCUS) = DZERO -18.320 - 8.6858*LOGF(XF) + 4.3429*LOGF(AA)
      631 SIGB = SIG
      632 CONTINUE
          RETURN
          END
```

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1 1.4           DATE 28AUG67       AT  091904
      SUBROUTINE PRINT (P,Q,R,AZ,IDAY,          Y, LMAX, T, C, U, V, X, H,
     1 JM, PHI, IMAX, F, TINS, IFOCUS, TINF, XFOCUS, PHIP, FT, NAME)
      DIMENSION          IDAY(4),              Y(120), T(50), C(120),
     1 U(120), V(120), X(440), H(440), PHI(440), F(440), TINS(440),
     2 TINF(30), XFOCUS(30),PHIP(30), FT(440), NAME(30)
      TYPE INTEGER P, Q, R
1045  PZ    = AZ*57.29578
      DO 1050 I = 1, IMAX
      PHI(I) = PHI(I)*57.29578
1050  X(I) = X(I)/1000.
      PRINT 1061,P,Q, R, PZ, IDAY
1061  FORMAT (1H1,59X,9HTABLES I-A5//47X,30H SOUND PROPAGATION SOUNDING OF/
     1 36X,31H THE ATMOSPHERE REPRESENTED BY A8, A8, 7H LAYERS 3(/)
     2 40X,24H Y = LEVELS IN METERS, /
     2 40X,52H   = SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,/
     2 40X,56H   = MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,/
     3 40X,41H C = SPEED OF SOUND IN METERS PER SECOND,/
     4 40X,45H U = WIND COMPONENT NORMAL TO THE SURFACES OF/
     5 46X,44H EXPANDING SOUND WAVES IN METERS PER SECOND,/
     6 40X,32H V = C + U IN METERS PER SECOND,/
     7 40X,37H T = TEMPERATURE IN DEGREES ABSOLUTE, 3(/)
     8 38X,10H AZIMUTH = ,F4.0, 9H DEGREES, 4X,12H DATE-TIME = 4A8,2(/)
     9 ,(9X,*Y*,12X,*C*,12X,*U*,12X,*V*,12X,*T*,3X))
1062  FORMAT (3X,2(5(F10.3, 3X)))
      LCOUNT = 0
      M = 40
      NNP = 1
      DO 1078 N = 1, LMAX
      LCOUNT = LCOUNT + 1
      IF (LCOUNT .GT. M) 1063, 1064
1063  LCOUNT = 1
      NNP = NNP + 1
      IF (L .GT. LMAX) GO TO 1080
      PRINT 1079, P, NNP
1064  I = N + 40*(NNP - 1) + 15*(NNP-2)*(NNP - 1)/2
      M = 40 + 15*(NNP - 1) - 15*(NNP - 2)*(NNP - 1)/2
      L = I + M
      IF (L.GT.LMAX) 1065, 1070
1065  IF (I.GT.LMAX) 1080, 1075
1070  PRINT 1062, Y(I),C(I),U(I),V(I),T(I),Y(L),C(L),U(L),V(L),T(L)
      GO TO 1078
1075  PRINT 1062, Y(I),C(I),U(I),V(I),T(I)
1078  CONTINUE
1079  FORMAT (1H1,8HTABLES IA6,15HCONTINUED, PARTI2//2X,2(9X,*Y*,12X,*C*,12X
     1 ,*U*,12X,*V*,12X,*T*,3X))
1080  PRINT 1081, P, Q, R
1081  FORMAT(1H1,59X,10HTABLES II-A5//19X,30H SOME SOUND PROPAGATION CHARAC
     1 43HTERISTICS OF THE ATMOSPHERE REPRESENTED BY A8,A8,7H LAYERS3(/)
     2 49X,29H IMAX = TOTAL NUMBER OF RAYS,/
     3 49X,30H   JM = NUMBER OF REFLECTING LAYERS,/
     4 48X,24HIFOCUS = NUMBER OF FOCI,/
     5 49X,25H LMAX = NUMBER OF LAYERS.3(/)
     6 23X,*DATE-TIME*,19X,*AZIMUTH (DEG.)*,9X,*IMAX*,11X,*JM*,10X,*IFOCUS*
     7 9X,*LMAX*)
      PRINT 1083, IDAY    , PZ, IMAX, JM, IFOCUS, LMAX
1083  FORMAT(14X, 4A8, F12.0, 11X, 4(I8, 6X))
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1 1.4          DATE 28AUG67       AT  091904
      PRINT 1102,P, Q, R, PZ, IDAY
 1102 FORMAT(1H0(/)62X11HTABLES III-A5//40X25H DISTANCE TO FOCAL POINTS
     1 35H AND VALUE OF SOUND INTENSITY THERE/41X18H IN THE ATMOSPHERE
     2 16H REPRESENTED BY A8, A8, 7H LAYERS 3(/)
     8 45X45H   (NO TABULAR ENTRIES IF THERE ARE NO FOCI),/
     7 45X52H    PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,/
     3 45X47H XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,/
     4 45X40H   TINF = INTENSITY AT EACH FOCUS IN DB,/
     9 45X26HDXDPHI2 = FOCAL-TYPE, VIZ./
     1 45X48H        = MIN, IF RAYS RANGE FIRST INWARD TOWARD/
     1 45X49H          SOUND-SOURCE BUT THEN BACK OUTWARD, OR/
     2 45X59H        = MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAY
     3 7HS RANGE/55X47H OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,/
     5 45X10HAZIMUTH = F4.0, 9H DEGREES, 4X12H DATE-TIME = 4A8, 2(/)
     6 47X*PHI*10X*XFOCUS*10X*TINF*9X*DXDPHI2*)
      PRINT 1103, (PHIP(I),XFOCUS(I), TINF(I), NAME(I), I = 1, IFOCUS)
 1103 FORMAT (36X3(5XF10.3),10X,A3)
      PRINT 1089, P, Q, R, PZ, IDAY
 1089 FORMAT (1H162X10HTABLES IV-A5//23X27H SOUND INTENSITY AT LANDING
     1 40H DISTANCES OF SOUND RAYS REPRESENTED BY A8, A8, 7H LAYERS 2(/)
     2 45X56H  PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,/
     3 45X53H    X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,/
     1 49X57H  = 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENTIH AT
     2 14H SOUNDING MAX,/
     4 45X55H    H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,/
     1 49X53H  = HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING
     2 12H BOTTOM-RAY,/
     5 45X44H    F = DIMENSIONLESS VALUE OF FOCUS FACTOR,/
     6 45X30H TINS = SOUND INTENSITY IN DB,/
     7 45X47H ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,/
     8 42X10H AZIMUTH = F4.0, 9H DEGREES, 4X12H DATE-TIME = 4A8, 2(/)
     9 1X2(6X*PHI*11X*X*12X*H*12X*F*10X*TINS*5X))
 1090 FORMAT (2X2(5(F10.3, 3X)))
      LCOUNT = 0
      NNP = 1
      M = 40
      DO 1096 N = 1, IMAX
      LCOUNT = LCOUNT + 1
      IF (LCOUNT .GT. M) 1091, 1094
 1091 LCOUNT = 1
      NNP = NNP + 1
      IF (P .EQ. 8HBRAVO    .AND. NNP .EQ. 2) 1092, 1093
 1092 PRINT 1104
 1093 IF (L .GT. IMAX) GO TO 1101
      PRINT 1099, P, NNP
 1094 I = N + 40*(NNP - 1) + 15*(NNP-2)*(NNP - 1)/2
      M = 40 + 15*(NNP - 1) - 15*(NNP - 2)*(NNP - 1)/2
      L = I + M
      IF (L.GT.IMAX) 1095, 1096
 1095 IF (I.GT.IMAX) 1101, 1097
 1096 PRINT 1090, PHI(I),X(I),H(I),F(I),TINS(I),PHI(L),X(L),H(L),F(L),
     1 TINS(L)
      GO TO 1098
 1097 PRINT 1090, PHI(I),X(I),H(I),F(I),TINS(I)
 1098 CONTINUE
 1099 FORMAT(1H110HTABLES IV-A6,15HCONTINUED, PART2//1X2(6X*PHI*11X*X*
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I 1.4           DATE 28AUG67        AT  091904
      1 12X*H*12X*F*10X*TINS*6X))
   11u4 FORMAT (1H05X45HFOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER
      1 59H SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE
      2 16H WHICH IS LINEAR/7X39H(H=400.).  THE RAY ZENITH FALLS OUTSIDE
      3 61H TOPPING-OUT LAYER (H=600.).  OTHER POSSIBLE FAILURES COMPARE
      4 19H ZENITH AND MAX-MIN/7X37HVALUES OF V RESPECTIVELY, AS FOLLOWS.
      5 62H AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN
      6 23H FOR A MIN OR LESS-THAN/7X19HFOR A MAX (H=500.).)
   11u1 RETURN
        END
```

```
1.4          DATE 28AUG67        AT  091904
      SUBROUTINE PRINT1 (P,Q,AZ,IDAY,Y,LMAX,DELV,DELDV,AAA,ZZZ,GGG)
      DIMENSION IDAY(4), Y(120), DELV(120), DELDV(120), AAA(120),
     1 ZZZ(120), GGG(120)
      TYPE INTEGER P, Q
      PZ = AZ*57.2957
      PRINT 2061, P, Q, Q, Q, PZ, IDAY
 2061 FORMAT (1H1,61X,9HTABLES V-A5//19X,28H COMPARISON OF SOUND-PROPAGA
     1 49HTION AND ITS HEIGHT-DERIVATIVE AT JOIN-POINTS OF A8,5HC SEG
     2  5HMENTS/31X,48H FITTED TO DATA-POINTS BY HALF-LAYERS SUBDIVIDED
     3 10H AT LOCAL A8, 6HC-MAXIMA3(/)
     4 40X,24H     Y = LEVEL IN METERS,/
     5 40X,55H DELV = CHANGE IN PROPAGATION SPEED ACROSS JOIN POINTS,/
     6 40X,35HDELDV = ITS SLOPE-DIFFERENCE THERE,/
     9 48X,38HDELV AND DELDV SET TO ZERO FOR Y = 0.,/
     7 48X,2HA,7HVERTEX COORDINATES OF THE A8,27HC SEGMENTS IN THE HALF-LAYE
     8 1HR/50X,31HSUPERJACENT TO THE Y-LEVELS ARE/
     1 41X,54H AAA = PROPAGATION-SPEED AT APEX IN METERS PER SECOND,/
     2 41X,46H ZZZ = VERTEX HEIGHT FROM SEA-LEVEL IN METERS,/
     3 41X,31H GGG = CURVATURE AT THE VERTEX,/
     4 37X,10H AZIMUTH = F4.0, 9H DEGREES, 4X,12H DATE-TIME = 4A8, 2(/)
     5 1X,2(5X*Y*8X*DELV*7X*DELDV*7X*AAA*8X*ZZZ*8X*GGG*4X))
 2062 FORMAT (2(F10.3,1X,2(1X,E10.3),2(1X,F10.5),1X,E10.3))
      LCOUNT = 0
      M = 40
      NNP = 1
      DO 2078 N = 1, LMAX
      LCOUNT = LCOUNT + 1
      IF (LCOUNT .GT. M) 2063, 2064
 2063 LCOUNT = 1
      NNP = NNP + 1
      IF (L .GT. LMAX) GO TO 2080
      PRINT 2079, P, NNP
 2064 I = N + 40*(NNP - 1) + 15*(NNP-2)*(NNP - 1)/2
      M = 40 + 15*(NNP - 1) - 15*(NNP - 2)*(NNP - 1)/2
      L = I + M
      IF (L .GT. LMAX) 2065, 2070
 2065 IF (I .GT. LMAX) 2080, 2075
 2070 PRINT 2062, Y(I), DELV(I), DELDV(I), AAA(I), ZZZ(I), GGG(I),
     1 Y(L), DELV(L), DELDV(L), AAA(L), ZZZ(L), GGG(L)
      GO TO 2078
 2075 PRINT 2062, Y(I), DELV(I), DELDV(I), AAA(I), ZZZ(I), GGG(I)
 2078 CONTINUE
 2079 FORMAT (1H1,8HTABLES VA6, 15HCONTINUED, PART,I2//1X,2(5X*Y*8X
     1 *DELV*7X*DELDV*7X*AAA*8X*ZZZ*8X*GGG*4X))
 2080 RETURN
      END
```

CHAPTER III

RESULTS IN ESTIMATING SOUND INTENSITY

TABLES I-ABLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 10, 1964 1636 CST

Y	C	U	V	T	Y	C	U	V	T
0.00	333.675	-0.634	333.041	277.050					
228.00	332.045	-1.131	330.914	274.350					
459.00	330.833	-2.354	328.479	272.350					
643.00	329.616	-2.314	327.302	270.350					
806.00	328.517	-2.787	325.730	268.550					
1061.00	328.150	-2.900	325.249	267.950					
1254.00	331.197	-1.948	329.249	272.950					
1451.00	330.711	-0.192	330.520	272.150					
1643.00	331.015	2.277	333.292	272.650					
1840.00	330.894	4.710	335.603	272.450					
2042.00	330.651	5.006	335.657	272.050					
2248.00	330.103	4.825	334.928	271.150					
2459.00	329.555	6.333	335.888	270.250					
2664.00	328.884	7.556	336.440	269.150					
2885.00	328.333	8.216	336.550	268.250					
3123.00	327.843	9.340	337.183	267.450					
3343.00	326.984	10.327	337.311	266.050					
3557.00	326.123	10.974	337.096	264.650					
3786.00	325.197	12.107	337.304	263.150					
4012.00	324.331	13.107	337.438	261.750					
4228.00	323.400	14.338	337.739	260.250					
4450.00	322.342	15.694	338.036	258.550					
4677.00	321.906	16.426	338.332	257.850					
4910.00	320.843	15.399	336.242	256.150					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
JAN 10, 1964 1636 CST	45	154	12	10	24

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 10, 1964 1636 CST

PHI	XFOCUS	TINF	DXDPHI2
2.261	25.720	106.946	MAX
7.087	99.263	60.040	MAX
7.539	69.504	77.903	MAX
8.159	101.018	63.631	MAX
8.355	80.253	76.919	MAX
8.998	103.058	63.803	MAX
9.130	168.145	60.104	MAX
9.287	129.201	68.794	MAX
9.594	120.005	68.576	MAX
9.888	119.907	68.175	MAX

TABLE IV-ABLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 10, 1964 1636 CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	28.169	1.626	189.929	119.471	7.121	52.509	1.961	0.021	89.793
0.222	27.895	1.626	102.924	116.895	7.128	50.250	1.981	0.025	91.080
0.444	27.627	1.626	52.222	114.033	7.136	48.421	2.001	0.029	86.279
0.666	27.366	1.627	35.354	112.421	7.143	46.899	2.022	0.034	87.065
0.888	27.111	1.628	26.948	111.323	7.150	45.606	2.042	0.039	87.745
1.110	26.863	1.630	21.927	110.508	7.150	0.000	0.000	0.000	0.000
1.331	26.621	1.632	18.601	109.872	7.150	67.305	2.408	0.041	86.324
1.553	26.386	1.634	16.244	109.360	7.181	61.580	2.413	0.059	86.706
1.775	26.157	1.637	14.495	108.941	7.212	58.495	2.418	0.094	86.927
1.997	25.935	1.640	13.153	108.593	7.242	56.319	2.423	0.124	87.902
2.219	25.719	1.643	12.096	108.302	7.273	54.666	2.428	0.155	88.691
2.219	0.000	0.000	0.000	0.000	7.304	53.351	2.433	0.186	89.352
2.219	25.719	1.643	161.628	119.561	7.335	52.272	2.438	0.219	89.917
2.462	25.686	1.648	30.648	112.351	7.365	51.364	2.444	0.253	90.422
2.705	25.554	1.653	16.766	109.776	7.396	50.587	2.449	0.288	90.871
2.948	25.413	1.659	14.854	109.298	7.427	49.913	2.454	0.324	91.288
3.191	25.272	1.666	13.800	109.027	7.457	49.321	2.459	0.367	89.731
3.434	25.134	1.673	13.114	108.853	7.457	0.000	0.000	0.000	0.000
3.677	25.001	1.680	12.648	108.742	7.457	49.321	2.459	0.013	86.047
3.919	24.873	1.688	12.337	108.678	7.526	68.985	2.479	0.115	84.524
4.162	24.751	1.697	12.149	108.654	7.595	60.189	2.499	0.081	87.095
4.405	24.636	1.706	12.065	108.665	7.663	55.616	2.519	0.129	88.231
4.648	24.527	1.715	12.076	108.707	7.732	52.516	2.539	0.170	89.789
4.891	24.424	1.726	12.178	108.780	7.800	50.164	2.559	0.206	91.133
5.134	24.326	1.736	12.374	108.884	7.869	48.267	2.580	0.240	86.357
5.377	24.239	1.747	12.668	109.018	7.937	46.675	2.601	0.270	87.181
5.620	24.156	1.759	13.072	109.184	8.006	45.304	2.622	0.299	87.353
5.863	24.079	1.771	13.601	109.384	8.075	44.099	2.643	0.326	87.959
6.106	24.009	1.784	14.282	109.621	8.143	43.025	2.664	0.357	88.543
6.349	23.946	1.797	15.148	109.900	8.143	0.000	0.000	0.000	0.000
6.592	23.889	1.811	16.252	110.226	8.143	43.025	2.664	0.001	65.853
6.835	23.838	1.825	17.673	110.608	8.156	98.387	2.686	0.008	80.541
7.077	23.794	1.840	19.556	111.064	8.169	81.913	2.708	0.011	74.087
7.077	0.000	0.000	0.000	0.000	8.182	74.511	2.730	0.020	82.445
7.077	23.794	1.840	0.000	81.272	8.195	70.026	2.752	0.029	82.658
7.088	95.822	1.860	0.004	81.440	8.208	66.911	2.774	0.038	86.399
7.092	74.487	1.880	0.005	82.445	8.221	64.567	2.796	0.048	86.885
7.099	64.990	1.900	0.009	86.792	8.234	62.709	2.818	0.058	86.485
7.107	59.302	1.921	0.013	87.474	8.247	61.180	2.841	0.068	86.814
7.114	55.401	1.941	0.017	88.336	8.259	59.888	2.863	0.077	87.221

TABLES IV-TABLE CONTINUED, PART 2

PHI	X	H	F	TINS
8.27[illegible]	58.771	2.865	0.089	87.592
8.27[illegible]	0.000	0.000	0.000	0.000
8.27[illegible]	58.771	2.865	0.014	86.937
8.343	79.788	2.908	0.125	80.105
8.414	69.550	2.931	0.074	82.697
8.485	64.173	2.954	0.118	86.981
8.556	60.540	2.978	0.156	86.992
8.627	57.798	3.001	0.191	87.241
8.698	55.596	3.025	0.222	88.240
8.769	53.754	3.049	0.252	89.151
8.839	52.170	3.074	0.279	89.974
8.910	50.780	3.098	0.305	90.758
8.981	49.541	3.123	0.333	91.539
8.981	0.000	0.000	0.000	0.000
8.981	49.541	3.123	0.001	89.658
8.995	100.640	3.145	0.008	80.684
9.008	85.373	3.167	0.012	82.962
9.022	78.488	3.189	0.021	82.423
9.036	74.300	3.211	0.031	82.449
9.049	71.377	3.233	0.042	82.571
9.063	69.107	3.255	0.052	82.817
9.077	67.407	3.277	0.063	85.956
9.090	65.953	3.299	0.073	86.590
9.104	64.717	3.321	0.083	86.850
9.118	63.645	3.343	0.095	87.119
9.118	0.000	0.000	0.000	0.000
9.118	146.981	3.800	0.005	67.540
9.131	166.101	3.821	0.119	71.939
9.144	142.926	3.842	0.011	62.943
9.158	130.307	3.863	0.018	65.940
9.171	122.107	3.884	0.025	74.564
9.184	116.201	3.906	0.032	77.993
9.197	111.671	3.927	0.038	78.381
9.211	107.939	3.948	0.045	78.798
9.224	104.806	3.969	0.051	79.490
9.237	102.114	3.991	0.058	80.170
9.250	99.759	4.012	0.065	80.954
9.250	0.000	0.000	0.000	0.000
9.250	99.759	4.012	0.007	80.126
9.281	126.501	4.033	0.055	72.226
9.312	115.112	4.055	0.036	78.022
9.343	107.769	4.076	0.056	78.818
9.373	102.613	4.098	0.073	80.044
9.404	98.606	4.119	0.088	80.359
9.435	95.317	4.141	0.101	81.630
9.466	92.524	4.162	0.114	82.420
9.496	90.094	4.184	0.126	83.104
9.527	87.944	4.206	0.138	83.705
9.558	86.016	4.228	0.151	84.220
9.558	0.000	0.000	0.000	0.000
9.558	86.016	4.228	0.005	82.816
9.587	118.751	4.250	0.034	75.745
9.617	107.112	4.272	0.037	78.902
9.648	101.212	4.294	0.062	80.403
9.678	97.219	4.316	0.083	80.983

PHI	X	H	F	TINS
9.705	94.162	4.338	0.102	81.955
9.735	91.659	4.360	0.118	82.665
9.764	89.523	4.383	0.134	83.265
9.794	87.651	4.405	0.147	83.789
9.823	85.978	4.427	0.160	82.773
9.853	84.461	4.450	0.174	80.515
9.853	0.000	0.000	0.000	0.000
9.853	84.461	4.450	0.004	73.906
9.881	118.529	4.472	0.030	77.360
9.909	106.900	4.495	0.035	78.944
9.938	101.137	4.517	0.060	80.424
9.966	97.304	4.540	0.081	80.958
9.994	94.406	4.563	0.101	81.885
10.023	92.054	4.585	0.119	82.553
10.051	90.059	4.608	0.135	83.114
10.079	88.317	4.631	0.149	83.601
10.108	86.765	4.654	0.163	84.041
10.136	85.359	4.677	0.177	82.967
10.136	0.000	0.000	0.000	0.000

TABLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
  = SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
  = MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
    EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 10, 1964 1636 CST

Y	C	U	V	T	Y	C	U	V	T
0.000	333.675	-0.634	333.041	277.050	4012.000	324.331	13.107	337.438	261.750
229.000	332.045	-1.131	330.914	274.350	4120.000	323.878	13.700	337.578	261.019
343.500	331.429	-1.768	329.661	273.333	4228.000	323.400	14.338	337.739	260.250
459.000	330.833	-2.354	328.479	272.350	4339.000	322.838	15.051	337.889	259.345
551.000	330.221	-2.375	327.846	271.343	4450.000	322.342	15.694	338.036	258.550
643.000	329.616	-2.314	327.302	270.350					
754.500	329.006	-2.541	326.464	269.350					
866.000	328.517	-2.787	325.730	268.550					
963.500	328.079	-2.930	325.149	267.835					
1061.000	328.150	-2.900	325.249	267.950					
1157.500	329.682	-2.539	327.142	270.458					
1254.000	331.197	-1.948	329.249	272.950					
1352.500	331.128	-1.166	329.961	272.835					
1451.000	330.711	-0.192	330.520	272.150					
1547.000	330.841	1.001	331.841	272.363					
1643.000	331.015	2.277	333.292	272.650					
1741.500	330.988	3.635	334.623	272.606					
1840.000	330.894	4.710	335.603	272.450					
1919.446	330.818	5.020	335.839	272.326					
1941.000	330.798	5.023	335.822	272.293					
2042.000	330.651	5.006	335.657	272.050					
2145.000	330.395	4.841	335.236	271.629					
2248.000	330.103	4.825	334.928	271.150					
2353.500	329.837	5.490	335.327	270.713					
2459.000	329.555	6.333	335.888	270.250					
2561.500	329.218	7.000	336.217	269.697					
2664.000	328.884	7.556	336.440	269.150					
2743.968	328.672	7.830	336.502	268.804					
2774.500	328.592	7.901	336.493	268.673					
2885.000	328.333	8.216	336.550	268.250					
3004.000	328.109	8.757	336.865	267.883					
3123.000	327.843	9.340	337.183	267.450					
3233.000	327.442	9.857	337.299	266.795					
3306.391	327.128	10.187	337.315	266.284					
3343.000	326.984	10.327	337.311	266.050					
3450.000	326.555	10.644	337.199	265.352					
3557.000	326.123	10.974	337.096	264.650					
3672.500	325.658	11.521	337.178	263.896					
3786.000	325.197	12.107	337.304	263.150					
3900.000	324.768	12.596	337.365	262.456					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
JAN 10, 1964 1636 CST	45	143	19	6	45

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 10, 1964 1636 CST

PHI	XFOCUS	TINF	DXDPHI2
5.855	22.622	105.155	MIN
7.843	48.977	90.433	MIN
8.759	54.705	88.165	MIN
9.159	126.090	68.266	MIN
9.176	128.854	69.032	MAX
9.765	96.409	88.427	MIN

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 10, 1964 1636 CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	27.305	1.624	159.053	118.973	7.419	59.478	2.451	0.042	86.436
0.247	26.984	1.625	85.980	116.408	7.432	57.672	2.454	0.064	88.174
0.493	26.676	1.625	44.450	113.652	7.445	56.400	2.456	0.086	89.678
0.740	26.384	1.626	30.709	112.154	7.457	55.431	2.459	0.104	91.693
0.986	26.105	1.628	23.935	111.180	7.457	0.000	0.000	0.000	0.000
1.233	25.839	1.630	19.970	110.499	7.457	55.431	2.459	0.104	91.693
1.479	25.587	1.633	17.432	110.012	7.541	51.925	2.477	0.223	87.766
1.726	25.350	1.636	15.739	109.670	7.624	50.306	2.496	0.442	90.866
1.972	25.127	1.639	14.608	109.445	7.707	49.454	2.517	0.852	93.985
2.219	24.920	1.643	13.468	109.189	7.791	49.060	2.538	2.332	98.831
2.219	0.000	0.000	0.000	0.000	7.874	49.006	2.562	3.226	96.963
2.219	24.920	1.643	13.468	109.189	7.874	0.000	0.000	0.000	0.000
2.554	24.644	1.649	11.960	108.815	7.874	49.006	2.562	3.226	96.963
2.889	24.380	1.656	10.934	108.583	7.928	49.199	2.578	1.104	96.487
3.224	24.123	1.664	10.164	108.434	7.982	49.608	2.596	0.619	93.224
3.559	23.887	1.673	9.578	108.341	8.035	50.273	2.615	0.397	90.977
3.894	23.659	1.682	9.122	108.290	8.089	51.294	2.638	0.258	89.011
4.229	23.442	1.693	8.764	108.348	8.143	52.904	2.664	0.143	86.435
4.564	23.236	1.704	8.484	108.511	8.143	0.000	0.000	0.000	0.000
4.899	23.040	1.716	8.267	108.704	8.143	52.904	2.664	0.143	86.435
5.233	22.856	1.728	8.102	109.321	8.158	53.627	2.672	0.109	85.483
5.568	22.680	1.742	11.475	111.943	8.172	54.658	2.682	0.076	84.074
5.568	0.000	0.000	0.000	0.000	8.187	56.200	2.693	0.047	89.959
5.568	22.680	1.741	11.475	111.943	8.202	58.964	2.708	0.000	86.893
5.820	22.623	1.752	77.404	117.477	8.217	1000.000	2.744	0.000	0.000
6.071	22.655	1.765	11.665	115.756	8.217	0.000	0.000	0.000	0.000
6.323	22.784	1.778	4.595	110.015	8.217	1000.000	2.846	0.000	0.000
6.574	23.048	1.795	2.317	108.678	8.228	75.179	2.856	0.000	69.173
6.826	23.541	1.814	1.155	108.280	8.239	71.073	2.865	0.030	75.491
7.077	24.543	1.840	0.566	108.721	8.250	68.856	2.872	0.050	77.607
7.077	0.000	0.000	0.000	0.000	8.261	67.338	2.879	0.068	78.942
7.077	24.543	1.840	0.566	108.721	8.272	66.178	2.885	0.081	79.803
7.141	24.962	1.848	0.451	109.242	8.272	0.000	0.000	0.000	0.000
7.204	25.518	1.858	0.327	109.915	8.272	66.178	2.885	0.081	79.803
7.267	26.324	1.869	0.204	111.965	8.344	62.008	2.918	0.163	83.672
7.330	27.745	1.884	0.000	63.706	8.417	59.670	2.944	0.251	86.254
7.393	1000.000	1.919	0.000	0.000	8.489	57.966	2.966	0.318	87.864
7.393	0.000	0.000	0.000	0.000	8.561	56.597	2.986	0.375	89.388
7.393	1000.000	2.446	0.000	0.000	8.633	55.441	3.004	0.521	91.635
7.406	62.554	2.449	0.000	83.125	8.633	0.000	0.000	0.000	0.000

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR (H=460.). THE RAY ZENITH FALLS OUTSIDE TOPPING-OUT LAYER (H=600.). OTHER POSSIBLE FAILURES COMPARE ZENITH AND MAX-MIN VALUES OF V RESPECTIVELY, AS FOLLOWS. AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN FOR A MIN OR LESS-THAN FOR A MAX (H=500.).

TABLES IV-GRAVO CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
8.635	55.441	3.004	0.521	91.635	9.708	0.000	0.000	0.000	0.000
8.702	54.845	3.022	1.196	97.610	9.708	96.463	4.339	5.222	96.403
8.772	54.712	3.041	5.422	98.421	9.737	96.422	4.361	10.656	104.166
8.842	55.004	3.064	0.748	93.777	9.766	96.409	4.383	1902.600	118.792
8.911	55.862	3.090	0.309	90.407	9.795	96.422	4.405	11.355	99.416
8.981	57.804	3.123	0.164	88.011	9.824	96.459	4.428	5.880	96.632
8.981	0.000	0.000	0.000	0.000	9.853	96.518	4.450	4.010	94.851
8.981	57.804	3.123	0.164	88.011	9.853	0.000	0.000	0.000	0.000
9.008	58.858	3.138	0.134	87.000					
9.036	60.177	3.154	0.103	85.758					
9.055	62.002	3.173	0.070	83.680					
9.086	64.922	3.197	0.034	80.938					
9.104	72.137	3.233	0.014	74.267					
9.104	0.000	0.000	0.000	0.000					
9.104	72.137	3.233	0.014	74.267					
9.106	74.186	3.241	0.012	71.473					
9.111	76.622	3.250	0.010	68.484					
9.114	79.929	3.261	0.007	66.636					
9.116	85.441	3.275	0.000	57.784					
9.121	1000.000	3.308	0.000	0.000					
9.121	0.000	0.000	0.000	0.000					
9.121	1000.000	3.803	0.000	0.000					
9.132	130.824	3.817	0.000	54.645					
9.142	129.374	3.834	0.029	68.178					
9.153	126.581	3.852	0.093	78.714					
9.163	126.310	3.873	0.130	76.827					
9.174	128.777	3.900	0.199	77.327					
9.174	0.000	0.000	0.000	0.000					
9.174	128.777	3.900	0.199	77.327					
9.189	126.109	3.934	0.067	71.974					
9.204	122.506	3.959	0.061	71.819					
9.220	119.419	3.979	0.069	72.586					
9.235	116.777	3.996	0.078	73.313					
9.250	114.480	4.012	0.087	73.956					
9.250	0.000	0.000	0.000	0.000					
9.250	114.480	4.012	0.087	73.956					
9.279	110.867	4.038	0.104	75.010					
9.308	107.906	4.061	0.122	75.908					
9.337	105.400	4.082	0.138	76.669					
9.366	103.230	4.102	0.155	77.333					
9.395	101.316	4.120	0.187	78.302					
9.395	0.000	0.000	0.000	0.000					
9.395	101.316	4.120	0.187	78.302					
9.426	99.775	4.140	0.262	79.901					
9.460	98.709	4.161	0.372	81.509					
9.495	97.963	4.182	0.539	83.187					
9.525	97.474	4.205	0.874	85.325					
9.556	97.207	4.228	1.317	87.126					
9.556	0.000	0.000	0.000	0.000					
9.556	97.207	4.228	1.317	87.126					
9.586	96.993	4.250	1.468	87.617					
9.616	96.798	4.272	1.719	88.318					
9.646	96.645	4.294	2.249	89.499					
9.676	96.534	4.316	3.245	91.101					
9.706	96.463	4.339	5.222	96.403					

TABLES I-ABLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 29, 1964 1610CST

Y	C	U	V	T	Y	C	U	V	T
0.000	336.673	-0.964	335.709	282.050					
150.000	336.195	0.490	336.685	281.250					
280.000	335.417	1.626	337.044	279.950					
407.000	334.637	2.444	337.082	278.650					
534.000	333.916	2.806	336.722	277.450					
673.000	333.495	3.531	337.026	276.750					
806.000	334.157	5.054	339.211	277.850					
941.000	334.998	6.276	341.273	279.250					
1085.000	335.477	6.791	342.268	280.050					
1219.000	335.417	7.142	342.559	279.950					
1352.000	335.237	7.227	342.464	279.650					
1496.000	334.878	7.594	342.472	279.050					
1623.000	334.698	8.124	342.822	278.750					
1742.000	334.277	8.143	342.420	278.050					
1865.000	333.916	8.434	342.350	277.450					
2000.000	333.916	9.336	343.252	277.450					
2130.000	333.916	10.447	344.364	277.450					
2267.000	334.036	11.992	346.029	277.650					
2407.000	333.916	12.970	346.886	277.450					
2520.000	333.916	13.478	347.394	277.450					
2650.000	333.374	13.670	347.044	276.550					
2781.000	332.892	13.781	346.672	275.750					
2928.000	332.408	13.280	345.689	274.950					
3060.000	331.561	14.477	346.038	273.550					
3217.000	331.136	15.494	346.630	272.850					
3346.000	330.347	15.011	345.358	271.550					
3490.000	330.103	15.267	345.370	271.150					
3624.000	329.738	15.420	345.158	270.550					
3771.000	328.823	15.366	344.188	269.050					
3940.000	327.966	15.047	343.013	267.650					
4073.000	327.475	15.973	343.449	266.850					
4228.000	326.800	17.083	343.882	265.750					
4371.000	325.876	17.204	343.080	264.250					
4517.000	325.012	16.895	341.907	262.850					
4664.000	324.145	16.109	340.254	261.450					
4801.000	323.587	15.167	338.754	260.550					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
JAN 29, 1964 1610CST	45	168	13	4	36

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 29, 1964 1610CST

PHI	XFOCUS	TINF	DXDPHI2
4.450	25.095	84.987	MAX
5.103	66.248	63.546	MAX
5.241	33.567	91.898	MAX
11.250	39.047	73.442	MAX

TABLES IV-ABLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 29, 1964 1610CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	0.000	1.000	0.000	5.144	29.975	0.369	0.028	92.267
0.229	0.432	0.000	1.000	132.979	5.151	28.622	0.381	0.032	92.326
0.459	0.863	0.002	1.000	126.959	5.158	27.495	0.394	0.037	92.402
0.688	1.295	0.004	1.000	123.437	5.166	26.536	0.407	0.042	92.607
0.918	1.726	0.007	1.000	120.939	5.166	0.000	0.000	0.000	0.000
1.147	2.158	0.011	1.000	119.001	5.166	33.314	0.676	0.962	97.160
1.376	2.589	0.016	1.000	117.418	5.401	32.437	0.684	0.424	97.928
1.606	3.021	0.021	1.000	116.080	5.637	26.655	0.692	0.253	92.482
1.835	3.452	0.028	1.000	114.921	5.872	23.671	0.701	0.384	96.034
2.065	3.883	0.035	1.000	113.899	6.108	21.731	0.710	0.501	97.030
2.294	4.314	0.043	1.000	112.985	6.344	20.335	0.719	0.612	98.253
2.523	4.745	0.052	1.000	112.158	6.579	19.273	0.729	0.723	99.290
2.753	5.176	0.062	1.001	111.404	6.815	18.436	0.739	0.838	102.240
2.982	5.606	0.073	1.001	110.710	7.051	17.759	0.749	0.957	102.634
3.212	6.037	0.085	1.001	110.068	7.286	17.202	0.760	1.084	103.022
3.441	6.467	0.097	1.001	109.470	7.522	16.738	0.771	1.223	103.418
3.670	6.897	0.111	1.001	108.911	7.757	16.349	0.782	1.374	103.759
3.900	7.327	0.125	1.001	108.387	7.993	16.020	0.794	1.544	104.237
4.129	7.757	0.140	1.001	107.892	8.229	15.741	0.806	1.763	104.856
4.359	8.187	0.156	1.001	107.425	8.229	0.000	0.000	0.000	0.000
4.359	0.000	0.000	0.000	0.000	8.229	15.741	0.806	4.121	108.182
4.359	8.187	0.156	0.005	94.454	8.440	15.629	0.818	3.060	107.043
4.432	24.462	0.168	0.077	94.819	8.652	15.487	0.830	2.807	106.774
4.506	16.744	0.179	0.073	102.088	8.864	15.361	0.843	3.107	107.241
4.579	16.066	0.191	0.118	104.160	9.076	15.252	0.856	3.530	107.811
4.653	14.394	0.203	0.159	95.339	9.287	15.161	0.869	4.088	108.455
4.726	13.205	0.216	0.195	96.745	9.499	15.085	0.883	4.832	109.181
4.800	12.294	0.228	0.229	97.907	9.711	15.023	0.897	5.858	110.012
4.873	11.563	0.241	0.260	98.895	9.923	14.974	0.911	7.357	110.991
4.947	10.957	0.254	0.289	99.752	10.135	14.937	0.926	9.744	112.196
5.020	10.440	0.267	0.316	100.508	10.346	14.911	0.941	14.445	113.862
5.094	9.992	0.280	0.347	101.257	10.346	0.000	0.000	0.000	0.000
5.094	0.000	0.000	0.000	0.000	10.346	14.911	0.941	0.075	113.862
5.094	9.992	0.280	0.000	86.880	10.434	16.198	0.955	0.147	103.938
5.101	63.665	0.293	0.005	67.355	10.521	16.732	0.969	0.290	103.424
5.108	47.679	0.305	0.006	84.195	10.608	17.145	0.984	0.365	103.072
5.115	40.861	0.318	0.010	88.136	10.696	17.496	0.998	0.426	102.819
5.122	36.660	0.331	0.015	91.145	10.783	17.808	1.013	0.477	102.607
5.130	33.780	0.343	0.019	92.526	10.870	18.093	1.028	0.522	102.443
5.137	31.644	0.356	0.023	97.135	10.958	18.358	1.043	0.562	102.287

TABLES IV-TABLE CONTINUED, PART 2

PHI	x	H	F	TINS	PHI	x	H	F	TINS
11.045	1[illegible].608	1.058	0.597	102.156	13.201	32.892	2.170	0.525	98.929
11.132	18.845	1.073	0.629	102.042	13.316	32.391	2.183	0.584	97.880
11.220	19.072	1.088	0.660	101.942	13.432	31.948	2.197	0.642	97.458
11.220	0.000	0.000	0.000	0.000	13.547	31.552	2.211	0.701	97.025
11.220	19.072	1.088	0.001	99.513	13.663	31.196	2.225	0.970	97.719
11.244	38.256	1.101	0.013	90.347	13.778	31.019	2.239	1.068	97.984
11.268	31.806	1.114	0.014	97.321	13.893	30.718	2.253	0.870	97.411
11.292	26.808	1.127	0.025	92.314	14.009	30.444	2.267	0.942	97.353
11.316	26.943	1.140	0.036	92.449	14.009	0.000	0.000	0.000	0.000
11.341	25.620	1.153	0.046	92.971	14.009	30.444	2.267	0.085	93.052
11.365	24.607	1.166	0.057	93.944	14.064	31.491	2.281	0.172	97.068
11.389	23.792	1.179	0.067	95.943	14.120	31.859	2.295	0.391	97.380
11.413	23.114	1.193	0.077	96.507	14.175	32.120	2.308	0.527	97.611
11.438	22.535	1.206	0.087	96.997	14.231	32.327	2.322	0.647	97.813
11.462	22.031	1.219	0.098	97.432	14.286	32.502	2.336	0.756	98.085
11.462	0.000	0.000	0.000	0.000	14.342	32.655	2.350	0.855	98.439
11.462	35053.295	1.528	0.001	5.535	14.398	32.791	2.364	0.946	98.731
11.486	64.371	1.537	0.000	37.730	14.453	32.917	2.379	1.028	98.977
11.504	55.619	1.547	0.015	79.100	14.509	33.032	2.393	1.102	99.187
11.526	50.937	1.556	0.024	82.410	14.564	33.141	2.407	1.177	99.382
11.547	47.740	1.566	0.031	84.277	14.564	0.000	0.000	0.000	0.000
11.569	45.319	1.575	0.038	85.793	14.564	33.141	2.407	0.065	96.927
11.590	43.379	1.585	0.044	86.183	14.596	33.996	2.419	0.117	92.260
11.611	41.766	1.594	0.051	87.338	14.628	34.383	2.431	0.209	92.509
11.633	40.390	1.604	0.057	88.518	14.660	34.693	2.442	0.254	92.560
11.654	39.193	1.613	0.063	89.447	14.691	34.962	2.454	0.289	92.573
11.675	38.137	1.623	0.070	90.569	14.723	35.205	2.466	0.319	92.571
11.675	0.000	0.000	0.000	0.000	14.755	35.429	2.478	0.345	94.426
11.675	58.227	1.947	0.033	77.595	14.787	35.638	2.490	0.368	94.357
11.713	54.087	1.953	0.050	79.889	14.818	35.836	2.502	0.389	94.312
11.744	51.971	1.959	0.079	81.790	14.850	36.024	2.514	0.409	94.270
11.776	50.318	1.965	0.095	82.773	14.882	36.205	2.526	0.429	94.239
11.812	48.947	1.971	0.110	83.571	14.882	0.000	0.000	0.000	0.000
11.846	47.776	1.976	0.124	84.255					
11.881	46.757	1.982	0.138	84.883					
11.915	45.858	1.988	0.152	85.446					
11.949	45.056	1.994	0.167	85.960					
11.985	44.336	2.000	0.182	86.438					
12.017	43.684	2.006	0.198	86.908					
12.017	0.000	0.000	0.000	0.000					
12.017	43.684	2.006	0.149	85.959					
12.101	41.910	2.018	0.187	87.205					
12.185	40.626	2.030	0.235	88.332					
12.269	39.588	2.042	0.272	89.144					
12.352	38.673	2.055	0.310	89.861					
12.436	37.903	2.067	0.349	90.022					
12.520	37.234	2.079	0.390	90.610					
12.604	36.646	2.092	0.432	91.158					
12.687	36.125	2.104	0.476	94.250					
12.771	35.661	2.117	0.523	94.349					
12.855	35.245	2.130	0.576	94.483					
12.855	0.000	0.000	0.000	0.000					
12.855	35.245	2.130	0.240	92.568					
12.970	34.153	2.143	0.336	92.294					
13.086	33.467	2.156	0.460	92.898					

TABLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
  = SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
  = MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
    EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 29, 1964 1610CST

Y	C	U	V	T	Y	C	U	V	T
0.000	333.073	-0.804	335.709	282.050	2526.000	333.916	13.478	347.394	277.450
150.000	333.145	0.490	336.685	281.250	2534.569	333.885	13.512	347.396	277.398
210.000	333.333	1.081	336.914	280.644	2592.000	333.676	13.600	347.276	277.051
260.000	333.417	1.626	337.044	279.950	2658.000	333.374	13.670	347.044	276.550
345.500	333.523	2.085	337.108	279.292	2719.500	333.126	13.766	346.892	276.139
359.000	333.523	2.189	337.111	279.125	2781.000	332.892	13.781	346.672	275.750
407.000	333.637	2.444	337.082	278.650	2854.500	332.670	13.459	346.129	275.383
470.500	333.751	2.634	336.885	278.007	2928.000	332.408	13.280	345.689	274.950
534.000	333.910	2.806	336.722	277.450	2997.000	331.980	13.789	345.769	274.242
603.500	334.015	3.096	336.711	276.950	3066.000	331.561	14.477	346.038	273.550
675.000	333.495	3.551	337.026	276.750	3141.500	331.348	15.094	346.441	273.198
734.500	333.747	3.260	336.007	277.169	3198.385	331.189	15.464	346.653	272.936
800.000	333.157	5.054	339.211	277.850	3217.000	331.136	15.494	346.630	272.850
873.500	333.593	5.734	340.327	278.576	3281.500	330.733	15.296	346.029	272.185
941.000	333.998	6.276	341.273	279.250	3346.000	330.347	15.011	345.358	271.550
1014.500	334.206	6.590	341.885	279.747	3418.000	330.196	15.097	345.294	271.303
1080.000	334.477	6.791	342.268	280.050	3475.439	330.122	15.253	345.375	271.181
1150.500	334.437	6.991	342.477	280.066	3490.000	330.103	15.267	345.370	271.150
1214.000	334.417	7.142	342.559	279.950	3557.000	329.960	15.362	345.322	270.915
1284.500	334.395	7.172	342.567	279.912	3624.000	329.738	15.420	345.158	270.550
1350.500	334.345	7.185	342.529	279.829	3697.500	329.298	15.421	344.718	269.828
1422.500	334.237	7.227	342.464	279.650	3771.000	328.823	15.366	344.188	269.050
1494.000	334.050	7.380	342.439	279.351	3858.500	328.371	15.137	343.508	268.312
1560.000	333.878	7.594	342.472	279.050	3946.000	327.966	15.047	343.013	267.650
1630.500	333.705	7.876	342.671	278.912	4009.500	327.715	15.427	343.143	267.241
1694.000	333.721	8.121	342.822	278.757	4073.000	327.475	15.973	343.449	266.850
1762.500	333.728	8.124	342.822	278.750	4150.500	327.161	16.588	343.749	266.339
1830.000	333.490	8.149	342.645	278.414	4211.756	326.876	17.017	343.892	265.873
1902.000	333.277	8.143	342.420	278.050	4228.000	326.800	17.083	343.882	265.750
1962.500	333.068	8.230	342.298	277.702	4299.500	326.353	17.228	343.581	265.023
2030.000	332.916	8.434	342.350	277.450	4371.000	325.876	17.204	343.080	264.250
2094.500	332.805	8.629	342.724	277.415	4444.000	325.439	17.106	342.545	263.541
2160.000	332.916	8.536	343.252	277.450	4517.000	325.012	16.895	341.907	262.850
2230.500	333.009	8.760	343.769	277.436					
2300.000	333.916	11.447	344.364	277.456					
2369.500	333.934	11.628	345.222	277.563					
2440.000	333.830	11.892	346.029	277.650					
2507.000	333.964	12.540	346.525	277.564					
2580.000	333.916	12.970	346.886	277.450					
2646.500	333.941	13.268	347.209	277.492					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
JAN 29, 1964 1610CST	45	189	26	3	73

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 29, 1964 1610CST

PHI	XFOCUS	TINF	DXDPHI2
9.618	14.907	104.422	MIN
11.630	42.298	62.152	MIN
13.855	30.326	95.255	MIN

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 29, 1964 1610CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	-0.000	1.000	0.000	5.221	1000.000	0.682	0.000	0.000
0.430	0.660	0.001	1.000	129.289	5.464	31.571	0.693	0.003	94.614
0.872	1.329	0.005	0.981	123.126	5.706	26.586	0.704	0.287	92.438
1.306	2.015	0.011	0.959	119.412	5.948	23.738	0.713	0.400	94.926
1.745	2.730	0.021	0.928	116.634	6.191	21.770	0.722	0.492	96.966
2.179	3.485	0.033	0.887	114.317	6.433	20.283	0.731	0.570	98.763
2.615	4.300	0.048	0.836	112.235	6.676	19.100	0.739	0.659	99.905
3.052	5.198	0.067	0.773	110.248	6.676	0.000	0.000	0.000	0.000
3.487	6.218	0.091	0.697	108.238	6.676	19.100	0.739	0.659	99.905
3.923	7.427	0.120	0.603	106.069	6.934	18.136	0.749	0.793	100.915
4.359	8.950	0.156	0.457	106.222	7.193	17.401	0.758	0.954	102.004
4.359	0.000	0.000	0.000	0.000	7.452	16.830	0.769	1.151	103.139
4.359	8.944	0.156	0.451	106.235	7.711	16.390	0.780	1.427	104.297
4.455	9.404	0.166	0.397	102.206	7.970	16.063	0.793	1.874	105.542
4.551	9.966	0.176	0.334	100.954	8.229	15.837	0.806	2.243	106.387
4.646	10.663	0.188	0.276	99.525	8.229	0.000	0.000	0.000	0.000
4.744	11.567	0.202	0.215	97.736	8.229	15.837	0.806	2.243	106.387
4.841	12.846	0.218	0.181	96.090	8.470	15.636	0.819	2.227	106.605
4.841	0.000	0.000	0.000	0.000	8.712	15.440	0.833	2.254	106.993
4.841	12.846	0.218	0.181	96.090	8.953	15.259	0.846	2.368	107.494
4.891	13.621	0.228	0.175	95.434	9.195	15.095	0.860	2.510	108.368
4.942	14.450	0.239	0.166	94.686	9.436	14.946	0.874	4.064	115.626
4.992	15.399	0.251	0.149	107.101	9.436	0.000	0.000	0.000	0.000
5.043	16.538	0.264	0.128	103.917	9.436	14.946	0.874	4.064	115.626
5.094	17.996	0.280	0.102	101.120	9.618	14.907	0.884	1435.916	133.784
5.094	0.000	0.000	0.000	0.000	9.800	14.946	0.896	3.571	111.104
5.094	17.996	0.280	0.102	101.120	9.982	15.061	0.909	1.678	108.839
5.118	18.896	0.288	0.087	100.120	10.164	15.271	0.924	0.977	107.431
5.142	20.031	0.298	0.071	99.044	10.346	15.615	0.941	0.662	106.635
5.166	21.555	0.309	0.052	97.217	10.346	0.000	0.000	0.000	0.000
5.190	23.895	0.323	0.029	94.788	10.346	15.615	0.941	0.662	106.635
5.214	29.209	0.344	0.011	88.683	10.456	15.885	0.952	0.547	106.212
5.214	0.000	0.000	0.000	0.000	10.565	16.215	0.965	0.439	104.983
5.214	29.209	0.344	0.011	88.683	10.674	16.639	0.979	0.336	103.644
5.218	29.919	0.345	0.009	87.163	10.783	17.216	0.995	0.240	102.341
5.217	30.883	0.347	0.007	96.903	10.892	18.072	1.014	0.204	101.001
5.218	32.276	0.350	0.004	93.972	10.892	0.000	0.000	0.000	0.000
5.220	34.697	0.353	0.000	92.647	10.892	18.072	1.014	0.204	101.001
5.221	1000.000	0.360	0.000	0.000	10.958	18.605	1.028	0.212	100.426
5.221	0.000	0.000	0.000	0.000	11.023	19.106	1.042	0.221	99.899

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR (H=400.). THE RAY ZENITH FALLS OUTSIDE TOPPING-OUT LAYER (H=600.). OTHER POSSIBLE FAILURES COMPARE ZENITH AND MAX-MIN VALUES OF V RESPECTIVELY, AS FOLLOWS. AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN FOR A MIN OR LESS-THAN FOR A MAX (H=500.).

TABLES IV-BRAVO CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
11.089	19.618	1.056	0.218	99.440	12.591	36.173	2.094	0.370	90.716
11.154	20.157	1.072	0.209	98.923	12.679	35.526	2.107	0.390	91.354
11.220	20.738	1.088	0.164	98.223	12.767	34.928	2.118	0.411	92.179
11.220	0.000	0.000	0.000	0.000	12.855	34.372	2.130	0.422	96.128
11.220	20.738	1.088	0.164	98.223	12.855	0.000	0.000	0.000	0.000
11.254	21.168	1.097	0.128	97.668	12.855	34.372	2.130	0.422	96.128
11.289	21.751	1.108	0.096	96.986	12.976	33.628	2.145	0.429	94.800
11.324	22.546	1.120	0.070	96.159	13.098	32.928	2.160	0.445	94.114
11.359	23.722	1.134	0.043	94.941	13.220	32.277	2.173	0.465	93.972
11.394	25.895	1.153	0.029	93.050	13.342	31.673	2.186	0.486	94.365
11.394	0.000	0.000	0.000	0.000	13.463	31.109	2.198	0.569	95.865
11.394	25.895	1.153	0.029	93.050	13.463	0.000	0.000	0.000	0.000
11.406	27.024	1.163	0.027	91.927	13.463	31.109	2.198	0.569	95.865
11.421	28.242	1.174	0.025	90.311	13.572	30.738	2.210	0.784	97.656
11.435	29.717	1.186	0.020	87.637	13.682	30.491	2.222	1.243	99.741
11.446	31.699	1.200	0.014	94.348	13.791	30.354	2.235	3.090	104.182
11.462	34.918	1.219	0.007	92.199	13.900	30.339	2.250	3.602	101.725
11.462	0.000	0.000	0.000	0.000	14.009	30.484	2.267	1.051	99.959
11.462	34.918	1.219	0.007	92.199	14.009	0.000	0.000	0.000	0.000
11.465	35.484	1.221	0.006	91.408	14.009	30.484	2.267	1.051	99.959
11.464	36.289	1.224	0.004	90.615	14.074	30.642	2.278	0.722	98.420
11.466	37.478	1.227	0.002	89.808	14.138	30.867	2.290	0.506	96.970
11.467	39.575	1.230	0.000	88.147	14.203	31.191	2.304	0.349	95.593
11.466	1000.000	1.240	0.000	0.000	14.268	31.665	2.319	0.233	94.374
11.466	0.000	0.000	0.000	0.000	14.333	32.402	2.337	0.215	93.893
11.466	1000.000	1.535	0.000	0.000	14.333	0.000	0.000	0.000	0.000
11.485	57.538	1.541	0.000	66.299	14.333	32.402	2.337	0.215	93.893
11.502	52.510	1.546	0.019	76.337	14.379	32.844	2.351	0.271	94.025
11.519	49.470	1.551	0.028	81.714	14.425	33.165	2.365	0.355	94.361
11.536	47.283	1.555	0.035	83.564	14.472	33.430	2.379	0.424	94.608
11.553	45.580	1.560	0.045	84.803	14.518	33.659	2.393	0.488	94.831
11.553	0.000	0.000	0.000	0.000	14.564	33.861	2.407	0.567	95.122
11.553	45.580	1.560	0.045	84.803	14.564	0.000	0.000	0.000	0.000
11.576	43.877	1.566	0.066	86.286	14.564	33.861	2.407	0.567	95.122
11.602	42.811	1.573	0.113	87.690	14.605	34.011	2.419	0.658	95.450
11.627	42.304	1.582	0.892	93.495	14.645	34.142	2.431	0.752	95.768
11.651	42.614	1.593	0.000	90.854	14.686	34.257	2.443	0.850	96.077
11.676	1000.000	1.620	0.000	0.000	14.727	34.360	2.455	0.954	96.383
11.676	0.000	0.000	0.000	0.000	14.767	34.452	2.466	0.369	93.974
11.676	1000.000	1.955	0.000	0.000	14.767	0.000	0.000	0.000	0.000
11.744	53.005	1.965	0.001	74.385	14.767	34.452	2.466	0.369	93.974
11.812	48.778	1.975	0.081	82.475	14.790	34.644	2.473	0.184	92.750
11.881	46.102	1.985	0.113	84.396	14.813	35.023	2.481	0.104	91.963
11.949	44.163	1.995	0.145	86.036	14.836	35.662	2.491	0.058	91.186
12.017	42.672	2.006	0.176	90.127	14.859	36.876	2.503	0.016	90.089
12.017	0.000	0.000	0.000	0.000	14.882	42.588	2.526	0.002	91.625
12.017	42.672	2.006	0.176	90.127	14.882	0.000	0.000	0.000	0.000
12.097	41.271	2.018	0.209	86.739	14.882	42.588	2.526	0.002	91.625
12.176	40.121	2.031	0.244	87.674	14.882	43.099	2.527	0.002	87.342
12.256	39.157	2.043	0.280	88.500	14.883	43.748	2.528	0.001	86.474
12.335	38.333	2.056	0.316	89.237	14.883	44.657	2.529	0.001	85.628
12.415	37.620	2.068	0.341	89.741	14.883	46.204	2.531	0.000	84.325
12.415	0.000	0.000	0.000	0.000	14.884	1000.000	2.535	0.000	0.000
12.415	37.620	2.068	0.341	89.741	14.884	0.000	0.000	0.000	0.000
12.503	36.873	2.081	0.353	90.091					

TABLES I-ABLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
  = SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
  = MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
    EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 31,1964 1139CST

Y	C	U	V	T	Y	C	U	V	T
0.000	337.269	-0.270	336.999	283.050					
133.000	337.210	1.403	338.612	282.950					
280.000	336.792	5.110	341.902	282.250					
433.000	336.613	8.768	345.381	281.950					
574.000	336.075	12.790	348.866	281.050					
754.000	336.673	17.653	354.326	282.050					
900.000	336.374	21.029	357.404	281.550					
1011.000	336.374	22.304	358.679	281.550					
1181.000	336.135	21.699	357.834	281.150					
1314.000	335.237	20.761	355.999	279.650					
1450.000	334.637	21.279	355.917	278.650					
1567.000	333.374	23.226	356.600	276.550					
1705.000	333.193	23.481	356.674	276.250					
1856.000	332.831	22.697	355.528	275.650					
1989.000	332.408	23.472	355.880	274.950					
2123.000	331.803	25.100	356.903	273.950					
2249.000	331.561	26.893	358.454	273.550					
2408.000	330.590	27.774	358.363	271.950					
2559.000	330.286	27.954	358.239	271.450					
2690.000	328.945	28.482	357.427	269.250					
2835.000	328.578	29.449	358.027	268.650					
3004.000	328.884	29.773	358.657	269.150					
3130.000	327.598	29.970	357.568	267.050					
3292.000	326.184	30.698	356.883	264.750					
3422.000	326.061	32.222	358.283	264.550					
3565.000	325.938	34.768	360.706	264.350					
3711.000	325.135	36.962	362.097	263.050					
3872.000	324.826	37.270	362.096	262.550					
4023.000	324.083	36.827	360.910	261.350					
4163.000	323.525	37.964	361.488	260.450					
4306.000	323.027	39.085	362.112	259.650					
4477.000	322.218	38.223	360.441	258.350					
4624.000	321.718	37.747	359.466	257.550					
4774.000	321.093	38.911	360.005	256.550					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
JAN 31,1964 1139CST	45	142	10	5	34

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 31,1964 1139CST

PHI	XFOCUS	TINF	DXDPHI2
6.236	4.878	113.356	MIN
9.836	6.025	110.248	MIN
15.387	7.660	106.953	MIN
20.919	46.097	85.264	MAX
21.451	185.119	37.959	MAX

TABLES IV-ABLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 31,1964 1139CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	0.000	1.000	0.000	9.711	0.000	0.000	0.000	0.000
0.280	0.272	0.000	1.000	137.002	9.711	6.033	0.286	4.562	120.306
0.559	0.543	0.001	1.000	130.981	9.956	6.032	0.297	4.634	117.869
0.839	0.815	0.003	1.000	127.460	10.200	6.096	0.308	2.076	113.153
1.119	1.086	0.005	1.000	124.961	10.445	6.172	0.319	1.822	112.478
1.398	1.358	0.008	1.000	123.023	10.689	6.253	0.330	1.690	112.039
1.678	1.629	0.012	1.000	121.440	10.933	6.339	0.342	1.604	111.694
1.958	1.901	0.016	1.000	120.102	11.178	6.427	0.354	1.541	111.398
2.237	2.172	0.021	1.000	118.943	11.422	6.519	0.367	1.492	111.135
2.517	2.444	0.027	1.000	117.920	11.666	6.612	0.379	1.452	110.892
2.796	2.715	0.033	1.000	117.006	11.911	6.707	0.392	1.418	110.667
3.076	2.986	0.040	1.000	116.179	12.155	6.803	0.406	1.389	110.454
3.356	3.257	0.048	1.000	115.424	12.400	6.901	0.419	1.364	110.251
3.635	3.528	0.056	1.000	114.730	12.644	7.000	0.433	1.341	110.054
3.915	3.799	0.065	1.000	114.087	12.644	0.000	0.000	0.000	0.000
4.195	4.070	0.075	1.000	113.489	12.644	7.000	0.433	4.586	115.393
4.474	4.341	0.085	1.000	112.929	12.878	7.043	0.446	2.143	112.037
4.754	4.612	0.096	1.000	112.404	13.111	7.117	0.459	1.622	110.736
5.034	4.882	0.108	1.000	126.364	13.345	7.196	0.473	1.525	110.370
5.313	5.153	0.120	1.000	117.077	13.579	7.279	0.486	1.468	110.105
5.593	5.423	0.133	1.000	115.282	13.812	7.364	0.500	1.427	109.883
5.593	0.000	0.000	0.000	0.000	14.046	7.450	0.514	1.395	109.684
5.593	5.423	0.133	0.349	114.074	14.280	7.538	0.529	1.370	109.502
5.633	4.953	0.140	0.761	118.833	14.514	7.627	0.544	1.348	109.330
6.076	4.885	0.147	5.310	125.156	14.747	7.716	0.559	1.329	115.543
6.320	4.880	0.154	17.059	124.480	14.981	7.807	0.574	1.311	113.481
6.562	4.907	0.161	4.935	121.772	14.981	0.000	0.000	0.000	0.000
6.804	4.953	0.169	3.307	118.832	14.981	7.807	0.574	0.568	112.499
7.047	5.013	0.177	2.648	118.071	15.212	7.667	0.587	1.560	120.557
7.289	5.082	0.186	2.286	117.507	15.443	7.661	0.599	20.515	121.390
7.531	5.160	0.194	2.055	117.033	15.674	7.678	0.612	4.922	116.865
7.773	5.243	0.203	1.894	116.605	15.905	7.706	0.625	3.409	115.742
8.016	5.331	0.213	1.775	116.202	16.137	7.742	0.639	2.808	115.032
8.256	5.423	0.222	1.683	113.255	16.368	7.783	0.652	2.476	114.419
8.503	5.519	0.232	1.609	112.909	16.599	7.828	0.666	2.261	111.350
8.742	5.617	0.242	1.549	112.591	16.830	7.876	0.680	2.108	110.993
8.985	5.718	0.253	1.499	112.293	17.061	7.928	0.695	1.993	110.692
9.227	5.821	0.264	1.457	112.014	17.292	7.981	0.709	1.902	110.431
9.469	5.926	0.275	1.421	111.749	17.523	8.036	0.724	1.828	110.199
9.711	6.033	0.286	1.388	117.848	17.754	8.093	0.739	1.766	109.989

TABLES IV-ABLE CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
17.985	0.152	0.754	1.712	109.790	21.453	113.222	4.304	0.001	52.344
17.985	0.000	0.000	0.000	0.000	21.453	108.510	4.305	0.001	53.628
17.985	0.152	0.754	0.119	98.218	21.454	104.837	4.305	0.001	54.720
18.131	0.576	0.768	0.214	100.321	21.455	101.868	4.305	0.001	55.667
18.276	0.776	0.782	0.374	102.547	21.455	99.402	4.306	0.001	56.503
18.424	0.969	0.796	0.446	103.148	21.456	97.310	4.306	0.001	57.345
18.570	9.083	0.811	0.499	103.493	21.456	0.000	0.000	0.000	0.000
18.716	9.215	0.825	0.540	103.719					
18.862	9.339	0.840	0.575	103.874					
19.008	9.458	0.855	0.605	103.983					
19.154	9.571	0.870	0.631	104.061					
19.301	9.680	0.885	0.653	104.115					
19.447	9.787	0.900	0.675	104.162					
19.447	0.000	0.000	0.000	0.000					
19.447	9.787	0.900	0.030	90.594					
19.504	10.512	0.911	0.056	92.734					
19.560	10.837	0.922	0.104	95.144					
19.617	11.095	0.933	0.128	95.849					
19.674	11.320	0.944	0.147	96.287					
19.731	11.522	0.955	0.164	96.598					
19.788	11.708	0.966	0.179	96.834					
19.845	11.883	0.977	0.192	97.021					
19.901	12.048	0.988	0.205	97.173					
19.958	12.206	1.000	0.216	97.300					
20.015	12.357	1.011	0.228	97.420					
20.015	0.000	0.000	0.000	0.000					
20.015	85.525	3.445	0.018	69.717					
20.102	70.585	3.457	0.027	73.057					
20.188	64.112	3.469	0.049	76.422					
20.275	59.777	3.481	0.065	78.248					
20.361	56.537	3.492	0.079	79.624					
20.448	53.969	3.504	0.093	80.743					
20.534	51.857	3.516	0.107	81.692					
20.621	50.072	3.528	0.121	82.519					
20.707	48.536	3.541	0.135	83.254					
20.794	47.193	3.553	0.148	83.916					
20.881	46.005	3.565	0.164	82.159					
20.881	0.000	0.000	0.000	0.000					
20.881	46.005	3.565	0.436	93.261					
20.937	46.075	3.579	0.893	92.650					
20.994	45.737	3.594	0.334	87.714					
21.051	45.366	3.608	0.316	87.544					
21.108	44.995	3.623	0.317	87.624					
21.165	44.635	3.637	0.324	87.791					
21.222	44.288	3.652	0.334	87.995					
21.279	43.956	3.667	0.346	88.217					
21.336	43.641	3.681	0.360	88.448					
21.393	43.340	3.696	0.375	88.682					
21.450	43.054	3.711	0.391	88.923					
21.450	0.000	0.000	0.000	0.000					
21.450	60.740	4.303	0.000	77.867					
21.450	179.421	4.303	0.000	41.143					
21.451	144.434	4.303	0.000	46.166					
21.452	128.885	4.304	0.000	48.823					
21.452	119.567	4.304	0.000	50.788					

TABLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = JAN 31,1964 1139CST

Y	C	U	V	T	Y	C	U	V	T
0.000	337.269	-0.270	336.999	283.050	2624.500	329.621	28.170	357.791	270.358
133.000	337.210	1.403	338.612	282.950	2690.000	328.945	28.482	357.427	269.250
209.500	337.007	3.147	340.154	282.610	2762.500	328.653	28.989	357.642	268.772
286.000	336.792	5.110	341.902	282.250	2835.000	328.578	29.449	358.027	268.650
359.500	336.712	6.900	343.612	282.115	2919.500	328.797	29.661	358.458	269.008
433.000	336.613	8.768	345.381	281.950	2987.190	328.866	29.804	358.670	269.122
503.500	336.297	10.761	347.058	281.421	3004.000	328.884	29.773	358.657	269.150
574.000	336.075	12.790	348.866	281.050	3067.000	328.336	29.849	358.185	268.255
664.000	336.358	15.276	351.634	281.522	3130.000	327.598	29.970	357.568	267.050
754.000	336.673	17.653	354.326	282.050	3211.000	326.808	30.243	357.051	265.763
827.000	336.562	19.472	356.034	281.863	3292.000	326.184	30.698	356.883	264.750
900.000	336.374	21.029	357.404	281.550	3357.000	326.052	31.343	357.395	264.535
955.500	336.370	21.885	358.255	281.543	3422.000	326.061	32.222	358.283	264.550
1011.000	336.374	22.304	358.679	281.550	3493.500	326.041	33.468	359.509	264.517
1027.671	336.363	22.328	358.691	281.531	3565.000	325.938	34.768	360.706	264.350
1096.000	336.316	22.160	358.477	281.453	3638.000	325.544	36.016	361.560	263.712
1181.000	336.135	21.699	357.834	281.150	3711.000	325.135	36.962	362.097	263.050
1247.500	335.717	21.171	356.888	280.450	3785.331	324.988	37.278	362.266	262.812
1314.000	335.237	20.761	355.999	279.650	3791.500	324.976	37.289	362.264	262.792
1382.000	334.968	20.828	355.796	279.201	3872.000	324.826	37.270	362.096	262.550
1450.000	334.637	21.279	355.917	278.650	3947.500	324.475	36.995	361.471	261.983
1508.500	333.981	22.269	356.250	277.558	4023.000	324.083	36.827	360.910	261.350
1567.000	333.374	23.226	356.600	276.550	4093.000	323.791	37.298	361.088	260.879
1636.000	333.218	23.534	356.752	276.292	4163.000	323.525	37.964	361.488	260.450
1655.329	333.211	23.555	356.766	276.280	4234.500	323.284	38.652	361.936	260.062
1705.000	333.193	23.481	356.674	276.250	4285.443	323.101	39.045	362.146	259.768
1780.500	333.029	23.055	356.084	275.978	4306.000	323.027	39.085	362.112	259.650
1856.000	332.831	22.697	355.528	275.650	4391.500	322.621	38.762	361.383	258.998
1922.500	332.638	22.934	355.572	275.330	4477.000	322.218	38.223	360.441	258.350
1989.000	332.408	23.472	355.880	274.950					
2056.000	332.096	24.216	356.312	274.433					
2123.000	331.803	25.100	356.903	273.950					
2186.000	331.698	26.056	357.754	273.776					
2249.000	331.561	26.893	358.454	273.550					
2297.040	331.266	27.311	358.577	273.063					
2328.500	331.073	27.452	358.524	272.745					
2408.000	330.590	27.774	358.363	271.950					
2483.500	330.470	27.881	358.351	271.753					
2490.957	330.452	27.900	358.352	271.723					
2559.000	330.286	27.954	358.239	271.450					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
JAN 31,1964 1139CST	45	149	19	1	69

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 31,1964 1139CST

PHI	XFOCUS	TINF	DXDPHI2
21.288	46.586	86.773	MIN

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENTIH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = JAN 31,1964 1139CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	-0.000	1.000	0.000	11.255	0.000	0.000	0.000	0.000
0.559	0.910	0.002	1.019	126.577	11.255	6.598	0.359	1.570	111.251
1.119	1.744	0.009	1.128	121.375	11.486	6.685	0.371	1.483	110.889
1.678	2.456	0.019	1.262	118.888	11.718	6.778	0.383	1.416	110.569
2.237	3.040	0.031	1.438	117.600	11.949	6.872	0.395	1.380	110.339
2.796	3.512	0.046	1.647	116.935	12.181	6.968	0.408	1.352	110.128
3.356	3.893	0.061	1.880	116.617	12.412	7.065	0.420	1.328	109.930
3.915	4.202	0.078	2.131	116.498	12.644	7.163	0.433	1.272	109.623
4.474	4.455	0.096	2.393	116.493	12.644	0.000	0.000	0.000	0.000
5.034	4.666	0.114	2.663	116.555	12.644	7.163	0.433	1.272	109.623
5.593	4.844	0.133	3.064	116.839	12.880	7.270	0.446	1.183	109.180
5.593	0.000	0.000	0.000	0.000	13.116	7.384	0.460	1.115	108.788
5.593	4.844	0.133	3.064	116.839	13.351	7.504	0.474	1.071	108.471
5.839	4.909	0.141	3.203	116.917	13.587	7.628	0.489	1.032	108.172
6.085	4.972	0.150	3.290	116.921	13.823	7.756	0.503	1.197	108.669
6.331	5.031	0.158	3.445	117.020	13.823	0.000	0.000	0.000	0.000
6.577	5.085	0.167	3.592	117.108	13.823	7.756	0.504	1.197	108.669
6.823	5.136	0.175	3.735	117.190	14.055	7.843	0.518	1.702	110.100
7.068	5.184	0.184	3.874	117.268	14.286	7.904	0.532	2.334	111.404
7.314	5.229	0.192	4.010	117.344	14.518	7.951	0.547	2.996	112.439
7.560	5.271	0.201	4.143	117.416	14.749	7.987	0.560	3.734	113.354
7.806	5.311	0.210	3.393	116.483	14.981	8.016	0.574	4.674	114.298
7.806	0.000	0.000	0.000	0.000	14.981	0.000	0.000	0.000	0.000
7.806	5.311	0.210	3.393	116.483	14.981	8.016	0.574	4.674	114.298
8.044	5.367	0.218	2.461	114.997	15.248	8.042	0.589	5.953	115.321
8.283	5.439	0.227	2.025	114.034	15.515	8.063	0.605	7.335	116.205
8.521	5.521	0.236	1.816	113.431	15.781	8.079	0.620	9.229	117.185
8.759	5.608	0.245	1.673	112.938	16.048	8.091	0.635	11.559	118.150
8.997	5.701	0.255	1.566	112.508	16.315	8.101	0.649	14.483	119.118
9.235	5.799	0.265	1.481	112.118	16.582	8.109	0.664	4.199	113.733
9.473	5.902	0.275	1.411	111.757	16.582	0.000	0.000	0.000	0.000
9.711	6.008	0.286	1.424	111.642	16.582	8.109	0.664	4.199	113.733
9.711	0.000	0.000	0.000	0.000	16.816	8.153	0.677	1.772	109.940
9.711	6.008	0.286	1.424	111.642	17.050	8.233	0.691	1.170	108.050
9.969	6.114	0.298	1.499	111.711	17.284	8.340	0.705	0.915	106.873
10.226	6.216	0.310	1.541	111.689	17.517	8.473	0.720	0.752	105.881
10.483	6.315	0.322	1.571	111.634	17.751	8.632	0.737	0.631	104.958
10.740	6.411	0.334	1.591	111.558	17.985	8.822	0.754	0.543	104.118
10.996	6.506	0.347	1.607	111.474	17.985	0.000	0.000	0.000	0.000
11.253	6.598	0.359	1.570	111.251	17.985	8.822	0.754	0.543	104.118

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR (H=400.). THE RAY ZENITH FALLS OUTSIDE TOPPING-OUT LAYER (H=600.). OTHER POSSIBLE FAILURES COMPARE ZENITH AND MAX-MIN VALUES OF V RESPECTIVELY, AS FOLLOWS. AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN FOR A MIN OR LESS-THAN FOR A MAX (H=500.).

TABLES IV-BRAVO CONTINUED, PART 2

PHI	X	H	F	TINS
18.151	8.973	0.767	0.489	103.513
18.316	9.145	0.781	0.438	102.871
18.482	9.338	0.795	0.392	102.213
18.647	9.556	0.811	0.349	101.502
18.813	9.807	0.827	0.324	100.951
18.813	0.000	0.000	0.000	0.000
18.813	9.807	0.827	0.324	100.951
18.940	10.007	0.840	0.314	100.640
19.060	10.218	0.854	0.300	100.268
19.193	10.443	0.869	0.283	99.828
19.320	10.687	0.884	0.265	99.330
19.447	10.953	0.900	0.242	98.731
19.447	0.000	0.000	0.000	0.000
19.447	10.953	0.900	0.242	98.731
19.523	11.130	0.910	0.225	98.277
19.599	11.324	0.921	0.208	97.790
19.676	11.536	0.932	0.193	97.300
19.752	11.769	0.943	0.178	96.772
19.828	12.027	0.955	0.123	94.961
19.828	0.000	0.000	0.000	0.000
19.828	12.027	0.955	0.123	94.961
19.866	12.229	0.962	0.087	93.307
19.903	12.536	0.969	0.058	91.385
19.940	13.002	0.978	0.036	88.990
19.978	13.826	0.989	0.011	83.276
20.015	17.514	1.011	0.002	73.050
20.015	0.000	0.000	0.000	0.000
20.015	17.514	1.011	0.002	73.050
20.016	18.089	1.013	0.002	72.479
20.017	18.753	1.015	0.001	71.340
20.018	19.642	1.017	0.001	69.332
20.020	21.108	1.020	0.000	42.825
20.021	1000.000	1.028	0.000	0.000
20.021	0.000	0.000	0.000	0.000
20.021	1000.000	3.449	0.000	0.000
20.092	78.851	3.459	0.001	55.806
20.162	70.999	3.468	0.037	74.380
20.233	66.027	3.477	0.051	76.399
20.304	62.372	3.485	0.064	77.830
20.375	59.485	3.493	0.076	78.986
20.375	0.000	0.000	0.000	0.000
20.375	59.485	3.493	0.076	78.986
20.476	56.298	3.506	0.094	80.426
20.577	53.850	3.518	0.116	81.689
20.678	51.919	3.532	0.140	82.869
20.779	50.391	3.548	0.173	84.531
20.881	49.216	3.565	0.214	85.884
20.881	0.000	0.000	0.000	0.000
20.881	49.216	3.565	0.214	85.884
20.951	48.531	3.578	0.242	86.695
21.021	47.930	3.592	0.276	87.617
21.092	47.420	3.606	0.326	88.633
21.162	47.003	3.622	0.405	90.180
21.232	46.683	3.638	0.685	93.593
21.232	0.000	0.000	0.000	0.000

PHI	X	H	F	TINS
21.232	46.683	3.638	0.685	93.593
21.276	46.590	3.649	2.729	96.674
21.319	46.617	3.661	0.875	97.114
21.363	46.798	3.675	0.297	91.731
21.406	47.229	3.691	0.131	89.125
21.450	48.195	3.711	0.065	87.148
21.450	0.000	0.000	0.000	0.000
21.450	48.195	3.711	0.065	87.148
21.463	48.687	3.719	0.051	86.509
21.477	49.335	3.728	0.037	85.747
21.490	50.282	3.738	-0.023	84.665
21.504	51.969	3.752	0.000	82.820
21.517	1000.000	3.785	0.000	0.000
21.517	0.000	0.000	0.000	0.000

TABLES I-AGLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 7, 1964 1620CS

Y	C	U	V	T	Y	C	U	V	T
0.000	333.615	2.546	336.161	276.950					
124.000	332.045	0.438	332.484	274.350					
249.000	331.197	2.025	333.222	272.950					
376.000	330.408	2.788	333.196	271.650					
487.000	329.738	2.654	332.392	270.550					
617.000	328.884	2.566	331.449	269.150					
739.000	327.721	2.355	330.076	267.250					
871.000	327.046	2.022	329.068	266.150					
990.000	326.984	2.089	329.073	266.050					
1099.000	328.027	3.093	331.120	267.750					
1210.000	328.150	4.572	332.721	267.950					
1323.000	327.537	4.786	332.323	266.950					
1476.000	327.537	4.964	332.500	266.950					
1612.000	327.046	5.245	332.291	266.150					
1750.000	326.307	5.563	331.870	264.950					
1899.000	325.506	6.127	331.633	263.650					
2041.000	325.012	7.014	332.026	262.850					
2185.000	324.269	8.326	332.595	261.650					
2310.000	323.462	9.071	332.533	260.350					
2469.000	323.152	10.910	334.061	259.850					
2631.000	322.841	12.664	335.505	259.350					
2784.000	322.342	13.643	335.986	258.550					
2941.000	321.656	15.352	337.008	257.450					
3089.000	321.718	17.411	339.129	257.550					
3240.000	321.406	19.910	341.316	257.050					
3382.000	320.780	22.241	343.021	256.050					
3514.000	320.467	24.147	344.614	255.550					
3636.000	320.529	26.545	347.075	255.650					
3759.000	320.090	28.844	348.935	254.950					
3910.000	319.651	30.823	350.474	254.250					
4064.000	319.462	34.150	353.612	253.950					
4207.000	319.273	38.205	357.478	253.650					
4340.000	319.084	43.126	362.210	253.350					
4502.000	318.706	49.674	368.380	252.750					
4654.000	318.328	55.599	373.926	252.150					
4822.000	317.949	58.546	376.495	251.550					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
FEB 7, 1964 1620CS	45	180	14	2	36

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 7, 1964 1620CS

PHI	XFOCUS	TINF	DXDPHI2
10.222	32.740	99.127	MAX
14.834	29.296	103.054	MAX

TABLES IV-ABLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENTIH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = FEB 7, 1964 1620CS

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	44.673	2.811	882.512	122.137	8.572	34.002	3.144	3.549	100.552
0.240	44.580	2.811	480.445	119.514	8.812	33.742	3.159	3.564	100.637
0.480	44.487	2.813	238.666	116.494	9.051	33.492	3.174	3.583	100.725
0.720	44.393	2.815	154.890	114.635	9.290	33.252	3.190	3.607	100.816
0.960	44.296	2.818	110.760	113.197	9.530	33.021	3.206	3.636	100.911
1.200	44.194	2.822	83.236	111.977	9.769	32.800	3.223	3.669	101.009
1.440	44.084	2.827	64.731	110.906	10.008	32.588	3.240	3.711	106.412
1.680	43.967	2.833	51.823	109.964	10.008	0.000	0.000	0.000	0.000
1.920	43.842	2.840	42.607	109.138	10.008	32.588	3.240	2.261	107.131
2.160	43.709	2.847	35.900	108.420	10.159	32.727	3.253	7.684	105.939
2.400	43.571	2.856	30.933	107.801	10.311	32.713	3.267	19.230	110.167
2.640	43.428	2.865	27.194	107.270	10.462	32.678	3.280	11.525	108.613
2.880	43.281	2.876	24.340	106.818	10.613	32.632	3.294	9.603	107.788
3.120	43.132	2.887	22.136	106.436	10.765	32.582	3.308	8.757	104.845
3.360	42.981	2.899	20.419	106.116	10.916	32.529	3.323	8.312	104.633
3.600	42.831	2.912	19.077	105.851	11.067	32.475	3.337	8.066	104.517
3.840	42.683	2.926	18.029	105.636	11.219	32.420	3.352	7.936	104.461
4.080	42.536	2.941	17.167	105.453	11.370	32.366	3.367	7.883	104.446
4.080	0.000	0.000	0.000	0.000	11.521	32.312	3.382	7.863	104.449
4.080	42.536	2.941	1.366	94.459	11.521	0.000	0.000	0.000	0.000
4.316	41.106	2.948	2.108	96.642	11.521	32.312	3.382	6.311	103.494
4.551	40.410	2.955	3.278	98.707	11.645	32.261	3.395	6.950	103.927
4.787	39.832	2.963	3.574	99.208	11.770	32.215	3.407	7.424	104.226
5.023	39.316	2.972	3.706	99.478	11.894	32.170	3.420	7.598	104.339
5.258	38.839	2.980	3.761	99.648	12.018	32.127	3.433	7.750	104.436
5.494	38.392	2.989	3.776	99.766	12.142	32.086	3.446	3.860	101.420
5.730	37.969	2.999	3.770	99.855	12.267	31.960	3.459	3.874	101.471
5.965	37.566	3.009	3.752	99.927	12.391	31.921	3.473	8.315	104.798
6.201	37.181	3.019	3.728	99.989	12.515	31.884	3.486	8.509	104.908
6.437	36.811	3.030	3.703	100.047	12.640	31.848	3.500	8.719	105.024
6.672	36.456	3.041	3.679	100.102	12.764	31.813	3.514	8.947	105.146
6.908	36.114	3.052	3.656	100.158	12.764	0.000	0.000	0.000	0.000
7.144	35.785	3.064	3.637	100.215	12.764	31.813	3.514	0.408	91.735
7.380	35.469	3.076	3.622	100.274	12.933	31.014	3.525	0.691	94.245
7.615	35.163	3.089	3.614	100.339	13.103	30.656	3.537	1.213	101.073
7.615	0.000	0.000	0.000	0.000	13.273	30.372	3.549	1.438	100.973
7.615	35.163	3.089	3.385	100.055	13.442	30.126	3.561	1.603	100.842
7.854	34.849	3.102	3.468	100.238	13.612	29.906	3.573	1.735	100.632
8.094	34.555	3.116	3.523	100.380	13.782	29.705	3.585	1.848	100.543
8.335	34.273	3.130	3.536	100.467	13.951	29.518	3.598	1.946	100.981

TABLES IV-ABLE CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
14.121	29.343	3.610	2.034	101.346	20.553	25.102	4.245	1.155	98.312
14.29J	29.179	3.623	2.115	102.943	20.751	24.911	4.258	1.232	98.658
14.46ᵢ	29.023	3.636	2.198	101.682	20.949	24.733	4.272	1.294	98.933
14.46ᵢ	0.000	0.000	0.000	0.000	21.148	24.565	4.285	1.347	99.167
14.46ᵢ	29.023	3.636	0.707	99.129	21.346	24.407	4.298	1.394	99.373
14.575	29.248	3.648	1.712	108.088	21.544	24.255	4.312	1.437	99.559
14.69ᵢ	29.286	3.660	9.317	126.339	21.742	24.111	4.326	1.477	99.730
14.805	29.29ᵢ	3.672	65.406	114.710	21.940	23.972	4.340	1.518	101.324
14.919	29.293	3.684	31.710	115.505	21.940	0.000	0.000	0.000	0.000
15.034	29.282	3.696	734.436	125.244	21.940	23.972	4.340	0.997	100.091
15.149	29.292	3.709	51.030	118.629	22.169	23.756	4.355	1.194	100.493
15.264	29.274	3.721	10.969	109.584	22.398	23.583	4.371	1.366	100.837
15.379	29.253	3.734	10.035	108.406	22.626	23.421	4.386	1.429	100.925
15.494	29.231	3.746	9.481	107.950	22.855	23.269	4.402	1.478	100.985
15.609	29.208	3.759	9.072	107.737	23.084	23.123	4.418	1.520	101.035
15.609	0.000	0.000	0.000	0.000	23.312	22.984	4.435	1.559	101.081
15.609	29.209	3.759	0.223	107.808	23.541	22.850	4.451	1.595	101.121
15.697	29.7ᵢ3	3.774	0.421	100.396	23.769	22.721	4.468	1.629	101.132
15.78ᵢ	29.983	3.788	0.848	100.748	23.998	22.597	4.485	1.662	101.142
15.873	30.149	3.803	1.080	100.854	24.227	22.478	4.502	1.696	105.754
15.96ᵢ	30.286	3.818	1.273	100.927	24.227	0.000	0.000	0.000	0.000
16.050	30.405	3.833	1.442	100.985	24.227	22.478	4.502	3.332	105.754
16.13ᵢ	30.512	3.848	1.594	101.023	24.410	22.420	4.517	2.379	102.622
16.227	30.609	3.864	1.732	101.057	24.594	22.345	4.531	2.050	102.024
16.315	30.699	3.879	1.859	101.049	24.778	22.268	4.546	2.018	101.979
16.403	30.783	3.894	1.976	101.000	24.961	22.191	4.561	2.015	101.991
16.49ᵢ	30.86ᵢ	3.910	2.095	100.676	25.145	22.116	4.576	2.023	102.027
16.49ᵢ	0.000	0.000	0.000	0.000	25.329	22.042	4.591	2.037	102.073
16.49ᵢ	30.86ᵢ	3.910	0.207	100.965	25.512	21.969	4.607	2.055	102.127
16.657	29.764	3.925	0.386	100.396	25.696	21.898	4.622	2.074	102.184
16.82ᵢ	29.376	3.939	0.838	101.289	25.880	21.829	4.638	2.095	102.244
16.987	29.097	3.954	1.088	102.723	26.063	21.761	4.654	2.118	102.186
17.15ᵢ	28.872	3.970	1.293	97.588	26.063	0.000	0.000	0.000	0.000
17.317	28.680	3.985	1.470	98.204	26.063	21.761	4.654	0.060	102.307
17.48ᵢ	28.511	4.000	1.628	98.698	26.143	22.550	4.670	0.116	101.149
17.647	28.360	4.016	1.772	99.112	26.222	22.861	4.687	0.237	101.120
17.812	28.222	4.032	1.905	99.468	26.301	23.093	4.704	0.305	101.044
17.977	28.094	4.048	2.029	99.782	26.381	23.285	4.720	0.363	100.978
18.14ᵢ	27.976	4.064	2.160	100.089	26.460	23.451	4.737	0.415	100.908
18.14ᵢ	0.000	0.000	0.000	0.000	26.539	23.600	4.754	0.463	100.804
18.14ᵢ	27.976	4.064	0.486	93.612	26.619	23.734	4.771	0.508	100.536
18.323	27.520	4.078	0.744	95.602	26.698	23.858	4.788	0.550	100.305
18.505	27.267	4.091	1.106	97.406	26.777	23.973	4.805	0.590	101.324
18.687	27.053	4.105	1.250	98.006	26.857	24.081	4.822	0.632	101.306
18.868	26.861	4.119	1.357	98.425	26.857	0.000	0.000	0.000	0.000
19.05ᵢ	26.686	4.133	1.446	98.757					
19.23ᵢ	26.522	4.148	1.524	99.038					
19.413	26.369	4.162	1.594	99.285					
19.595	26.225	4.177	1.660	99.507					
19.777	26.088	4.192	1.721	99.710					
19.95ᵢ	25.957	4.207	1.784	99.910					
19.95ᵢ	0.000	0.000	0.000	0.000					
19.95ᵢ	25.957	4.207	0.509	94.464					
20.157	25.553	4.220	0.746	96.261					
20.355	25.312	4.232	1.047	97.813					

TABLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
  = SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,
  = MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
    EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 7, 1964 1620CS

Y	C	U	V	T	Y	C	U	V	T
0.000	333.615	2.546	336.161	276.950	2389.500	323.267	9.948	333.216	260.036
124.000	332.045	0.438	332.484	274.350	2469.000	323.152	10.910	334.061	259.850
186.500	331.571	1.053	332.624	273.567	2550.000	323.009	11.838	334.847	259.621
249.000	331.197	2.025	333.222	272.950	2631.000	322.841	12.664	335.505	259.350
310.641	330.808	2.501	333.309	272.309	2707.500	322.615	13.154	335.769	258.988
312.500	330.796	2.513	333.309	272.290	2784.000	322.342	13.643	335.986	258.550
376.000	330.408	2.788	333.196	271.650	2862.500	321.964	14.426	336.390	257.944
431.500	330.075	2.771	332.846	271.104	2941.000	321.656	15.352	337.008	257.450
487.000	329.738	2.654	332.392	270.550	3015.000	321.665	16.328	337.993	257.464
552.000	329.338	2.614	331.952	269.894	3089.000	321.718	17.411	339.129	257.550
617.000	328.884	2.566	331.449	269.150	3164.500	321.607	18.637	340.244	257.371
678.000	328.290	2.475	330.765	268.180	3240.000	321.406	19.910	341.316	257.050
739.000	327.721	2.355	330.076	267.250	3311.000	321.097	21.093	342.190	256.556
805.000	327.311	2.170	329.481	266.582	3382.000	320.780	22.241	343.021	256.050
871.000	327.046	2.022	329.068	266.150	3448.000	320.583	23.169	343.752	255.736
934.500	326.901	1.964	328.866	265.915	3514.000	320.467	24.147	344.614	255.550
998.000	326.984	2.089	329.073	266.050	3575.000	320.506	25.312	345.819	255.613
1048.500	327.491	2.502	329.993	266.875	3636.000	320.529	26.545	347.075	255.650
1099.000	328.027	3.093	331.120	267.750	3697.500	320.336	27.750	348.085	255.341
1154.500	328.195	3.890	332.085	268.024	3759.000	320.090	28.844	348.935	254.950
1210.000	328.150	4.572	332.721	267.950	3834.500	319.849	29.800	349.649	254.565
1230.658	328.038	4.738	332.777	267.768	3910.000	319.651	30.823	350.474	254.250
1266.500	327.845	4.765	332.610	267.452	3987.000	319.541	32.343	351.884	254.076
1323.000	327.537	4.786	332.323	266.950	4064.000	319.462	34.150	353.612	253.950
1399.500	327.525	4.873	332.398	266.931	4135.500	319.369	36.040	355.410	253.803
1473.059	327.536	4.964	332.501	266.949	4207.000	319.273	38.205	357.478	253.650
1476.000	327.537	4.964	332.500	266.950	4273.500	319.188	40.559	359.747	253.515
1544.000	327.339	5.094	332.433	266.627	4340.000	319.084	43.126	362.210	253.350
1612.000	327.046	5.245	332.291	266.150	4421.000	318.905	46.383	365.288	253.066
1681.000	326.692	5.389	332.080	265.574	4502.000	318.706	49.674	368.380	252.750
1750.000	326.307	5.563	331.870	264.950					
1824.500	325.890	5.809	331.699	264.272					
1899.000	325.506	6.127	331.633	263.650					
1970.000	325.257	6.523	331.779	263.246					
2041.000	325.012	7.014	332.026	262.850					
2113.000	324.666	7.671	332.337	262.291					
2185.000	324.269	8.326	332.595	261.650					
2203.360	324.142	8.471	332.613	261.445					
2247.500	323.837	8.676	332.513	260.954					
2310.000	323.462	9.071	332.533	260.350					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
FEB 7, 1964 1620CS	45	180	24	6	70

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 7, 1964 1620CS

PHI	XFOCUS	TINF	DXDPHI2
10.258	32.329	103.511	MIN
11.019	32.500	102.527	MAX
11.545	32.417	99.843	MIN
12.138	32.805	95.794	MAX
14.356	29.622	101.705	MIN
16.097	32.710	89.329	MAX

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENTIH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = FEB 7, 1964 1620CS

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	45.265	2.819	1061.884	122.826	7.615	34.315	3.089	4.356	101.362
0.236	45.199	2.820	602.993	120.381	7.876	34.041	3.103	4.060	101.126
0.472	45.115	2.821	247.792	116.535	8.137	33.763	3.118	3.885	101.006
0.708	45.017	2.824	142.229	114.143	8.397	33.488	3.133	3.789	100.968
0.944	44.904	2.828	95.139	112.419	8.658	33.218	3.149	3.722	100.961
1.180	44.781	2.833	69.713	111.092	8.919	32.955	3.165	3.991	101.334
1.416	44.647	2.839	54.264	110.030	8.919	0.000	0.000	0.000	0.000
1.652	44.506	2.846	44.054	109.152	8.919	32.955	3.164	3.991	101.334
1.886	44.359	2.854	36.856	108.406	9.137	32.772	3.178	4.697	107.369
2.124	44.206	2.862	22.265	106.248	9.354	32.625	3.192	5.688	106.601
2.124	0.000	0.000	0.000	0.000	9.572	32.507	3.208	7.043	107.053
2.124	44.206	2.862	22.265	106.248	9.790	32.417	3.223	9.436	108.609
2.368	43.905	2.872	13.006	103.972	10.008	32.355	3.240	15.775	110.622
2.613	43.509	2.882	9.709	102.781	10.008	0.000	0.000	0.000	0.000
2.857	43.067	2.892	8.077	102.071	10.008	32.355	3.240	15.775	110.622
3.102	42.597	2.902	7.018	101.555	10.169	32.332	3.253	41.466	115.148
3.346	42.110	2.911	6.253	101.154	10.330	32.331	3.266	50.427	112.724
3.591	41.614	2.921	5.666	100.829	10.491	32.352	3.281	14.891	111.174
3.835	41.111	2.931	5.198	100.560	10.651	32.397	3.295	8.267	108.959
4.080	40.607	2.941	4.724	100.252	10.812	32.469	3.311	9.437	111.770
4.080	0.000	0.000	0.000	0.000	10.812	0.000	0.000	0.000	0.000
4.080	40.607	2.941	4.724	100.252	10.812	32.469	3.311	9.437	111.770
4.319	40.095	2.951	4.297	99.951	10.954	32.497	3.325	31.074	112.067
4.556	39.576	2.960	3.992	99.744	11.096	32.496	3.339	46.509	115.062
4.797	39.058	2.969	3.755	99.593	11.238	32.479	3.354	18.769	112.588
5.036	38.543	2.979	3.558	99.474	11.379	32.452	3.368	13.098	111.630
5.274	38.033	2.988	3.389	99.379	11.521	32.418	3.382	45.493	113.667
5.513	37.529	2.997	3.242	99.302	11.521	0.000	0.000	0.000	0.000
5.752	37.032	3.006	3.111	99.239	11.521	32.418	3.382	45.493	113.667
5.991	36.544	3.015	3.150	99.408	11.639	32.429	3.394	10.878	113.724
5.991	0.000	0.000	0.000	0.000	11.756	32.478	3.407	5.047	112.466
5.991	36.544	3.015	3.150	99.408	11.874	32.556	3.420	3.445	106.683
6.229	36.122	3.024	3.374	99.806	11.991	32.662	3.434	2.592	106.876
6.455	35.748	3.033	3.578	100.152	12.109	32.799	3.448	6.890	105.964
6.687	35.407	3.043	3.742	100.430	12.109	0.000	0.000	0.000	0.000
6.919	35.095	3.054	3.915	100.704	12.109	32.799	3.448	6.890	105.964
7.151	34.809	3.065	4.118	100.994	12.240	32.736	3.464	2.829	106.414
7.383	34.549	3.077	4.369	101.316	12.371	32.555	3.478	1.700	106.686
7.615	34.315	3.089	4.356	101.362	12.502	32.337	3.491	1.480	114.416
7.615	0.000	0.000	0.000	0.000	12.633	32.105	3.503	1.393	99.246

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR (H=400.). THE RAY ZENITH FALLS OUTSIDE TOPPING-OUT LAYER (H=600.). OTHER POSSIBLE FAILURES COMPARE ZENITH AND MAX-MIN VALUES OF V RESPECTIVELY, AS FOLLOWS. AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN FOR A MIN OR LESS-THAN FOR A MAX (H=500.).

TABLES IV-BRAVO CONTINUED, PART 2

PHI	X	H	F	TINS
12.764	31.867	3.514	1.298	99.095
12.764	0.000	0.000	0.000	0.000
12.764	31.867	3.514	1.298	99.095
12.936	31.525	3.528	1.190	99.225
13.108	31.175	3.541	1.160	99.605
13.279	30.832	3.553	1.158	100.028
13.451	30.498	3.564	1.163	100.626
13.623	30.174	3.575	1.331	101.817
13.623	0.000	0.000	0.000	0.000
13.623	30.174	3.575	1.331	101.817
13.791	29.942	3.586	1.818	103.192
13.956	29.782	3.597	2.647	105.007
14.125	29.677	3.609	4.405	107.839
14.293	29.626	3.622	15.372	108.473
14.460	29.633	3.636	24.719	112.251
14.460	0.000	0.000	0.000	0.000
14.460	29.633	3.636	24.719	112.251
14.587	29.647	3.647	15.405	110.645
14.715	29.666	3.659	10.100	108.845
14.842	29.697	3.671	6.489	106.969
14.969	29.743	3.684	4.514	105.802
15.096	29.806	3.698	3.200	104.623
15.096	0.000	0.000	0.000	0.000
15.096	29.806	3.698	3.200	104.623
15.199	29.877	3.709	2.435	103.807
15.301	29.968	3.720	1.918	102.994
15.404	30.081	3.733	1.557	102.323
15.506	30.219	3.745	1.277	101.656
15.609	30.386	3.759	0.926	100.984
15.609	0.000	0.000	0.000	0.000
15.609	30.386	3.759	0.926	100.984
15.692	30.585	3.771	0.662	100.410
15.775	30.864	3.784	0.481	99.976
15.859	31.246	3.798	0.347	99.523
15.942	31.786	3.815	0.236	99.074
16.025	32.617	3.834	0.348	106.552
16.025	0.000	0.000	0.000	0.000
16.025	32.617	3.835	0.348	106.552
16.116	32.701	3.856	2.464	106.873
16.212	32.467	3.872	0.724	111.757
16.305	32.199	3.886	0.669	99.307
16.398	31.932	3.899	0.672	99.122
16.492	31.673	3.910	0.718	99.119
16.492	0.000	0.000	0.000	0.000
16.492	31.673	3.910	0.718	99.119
16.644	31.318	3.927	0.835	99.458
16.797	31.004	3.943	0.904	99.823
16.950	30.712	3.959	0.942	100.219
17.103	30.434	3.973	0.971	100.827
17.256	30.168	3.987	1.044	101.850
17.256	0.000	0.000	0.000	0.000
17.256	30.168	3.987	1.044	101.850
17.433	29.905	4.003	1.192	103.555
17.610	29.674	4.018	1.306	108.160
17.787	29.462	4.034	1.381	97.698
17.964	29.263	4.049	1.438	97.931
18.142	29.074	4.064	1.447	98.015
18.142	0.000	0.000	0.000	0.000
18.142	29.074	4.064	1.447	98.015
18.316	28.887	4.079	1.428	98.013
18.490	28.702	4.093	1.423	98.054
18.664	28.520	4.107	1.422	98.106
18.838	28.341	4.122	1.424	98.166
19.012	28.165	4.135	1.392	98.123
19.012	0.000	0.000	0.000	0.000
19.012	28.165	4.136	1.392	98.123
19.201	27.968	4.150	1.342	98.024
19.391	27.770	4.165	1.317	98.005
19.580	27.573	4.179	1.303	98.021
19.769	27.377	4.193	1.295	98.057
19.958	27.184	4.207	1.259	97.994
19.958	0.000	0.000	0.000	0.000
19.958	27.184	4.207	1.259	97.994
20.154	26.977	4.221	1.209	97.887
20.350	26.768	4.235	1.185	97.866
20.546	26.561	4.248	1.171	97.883
20.742	26.355	4.261	1.164	97.923
20.938	26.152	4.274	1.221	98.199
20.938	0.000	0.000	0.000	0.000
20.938	26.152	4.274	1.221	98.199
21.138	25.968	4.286	1.359	98.726
21.339	25.806	4.300	1.485	99.163
21.539	25.657	4.313	1.580	99.483
21.740	25.518	4.326	1.667	99.764
21.940	25.388	4.340	1.696	99.883
21.940	0.000	0.000	0.000	0.000
21.940	25.388	4.340	1.696	99.883
22.176	25.235	4.356	1.678	99.889
22.411	25.085	4.372	1.682	99.951
22.647	24.938	4.388	1.693	100.029
22.882	24.795	4.405	1.707	100.116
23.117	24.655	4.421	1.816	100.435
23.117	0.000	0.000	0.000	0.000
23.117	24.655	4.421	1.816	100.435
23.339	24.540	4.437	2.063	101.029
23.561	24.442	4.452	2.341	101.612
23.783	24.355	4.469	2.601	102.101
24.005	24.277	4.485	2.900	102.601
24.227	24.209	4.502	3.271	103.149
24.227	0.000	0.000	0.000	0.000

TABLES I-ABLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 13, 1964 1639CST

Y	C	U	V	T	Y	C	U	V	T
0.000	335.717	0.357	336.074	280.450					
100.000	334.337	-0.269	334.068	278.150					
236.000	333.856	-1.847	332.009	277.350					
365.000	333.254	-3.203	330.051	276.350					
505.000	332.892	-3.323	329.569	275.750					
639.000	333.073	-1.607	331.465	276.050					
775.000	333.193	0.248	333.442	276.250					
922.000	333.193	1.768	334.961	276.250					
1054.000	333.193	3.900	337.093	276.250					
1206.000	333.555	5.797	339.351	276.850					
1351.000	332.529	6.784	339.313	275.150					
1489.000	332.045	7.566	339.611	274.350					
1638.000	331.682	9.186	340.869	273.750					
1770.000	331.379	10.976	342.355	273.250					
1903.000	330.894	11.803	342.697	272.450					
2038.000	330.042	12.233	342.275	271.050					
2175.000	329.189	11.791	340.980	269.650					
2324.000	328.517	12.457	340.974	268.550					
2454.000	328.088	15.296	343.384	267.850					
2586.000	327.598	17.235	344.834	267.050					
2731.000	327.291	16.783	344.074	266.550					
2878.000	326.554	15.579	342.132	265.350					
3004.000	326.123	16.322	342.445	264.650					
3121.000	325.876	18.849	344.725	264.250					
3263.000	325.382	21.591	346.974	263.450					
3395.000	325.074	25.346	350.420	262.950					
3542.000	324.950	30.061	355.011	262.750					
3667.000	325.382	34.845	360.227	263.450					
3819.000	325.382	39.509	364.891	263.450					
3935.000	325.074	42.379	367.452	262.950					
4066.000	324.950	43.349	368.299	262.750					
4199.000	324.517	46.289	370.805	262.050					
4348.000	324.269	49.423	373.692	261.650					
4485.000	323.773	51.444	375.217	260.850					
4638.000	323.338	53.089	376.428	260.150					
4780.000	322.903	55.716	378.619	259.450					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
FEB 13, 1964 1639CST	45	254	20	6	36

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 13, 1964 1639CST

PHI	XFOCUS	TINF	DXDPHI2
4.731	16.231	110.526	MAX
6.727	16.118	115.160	MIN
8.010	54.251	74.195	MAX
11.035	42.313	74.330	MAX
11.358	49.881	78.271	MAX
21.335	22.916	99.529	MAX

TABLES IV-ABLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = FEB 13, 1964 1639CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	18.156	0.991	248.085	124.446	8.035	44.387	1.392	0.024	87.106
0.235	18.021	0.991	134.591	121.855	8.066	39.671	1.404	0.039	92.065
0.469	17.888	0.992	68.384	118.979	8.097	36.645	1.416	0.053	94.490
0.704	17.759	0.992	46.376	117.355	8.127	34.469	1.428	0.067	95.705
0.939	17.633	0.994	35.429	116.248	8.158	32.798	1.440	0.081	97.822
1.174	17.510	0.995	28.916	115.426	8.189	31.456	1.452	0.096	95.366
1.408	17.391	0.997	24.628	114.789	8.220	30.344	1.465	0.110	96.235
1.643	17.275	0.999	21.620	114.281	8.250	29.400	1.477	0.124	96.999
1.878	17.162	1.002	19.418	113.871	8.281	28.584	1.489	0.140	97.729
2.112	17.054	1.005	17.761	113.539	8.281	0.000	0.000	0.000	0.000
2.347	16.949	1.008	16.493	113.271	8.281	28.584	1.489	1.083	100.084
2.582	16.849	1.012	15.516	113.057	8.416	28.000	1.503	0.599	99.629
2.816	16.752	1.016	14.763	112.891	8.550	27.101	1.517	0.551	99.910
3.051	16.660	1.020	14.191	112.768	8.685	26.464	1.531	0.741	101.030
3.286	16.571	1.025	13.771	112.683	8.819	26.002	1.546	0.980	101.531
3.521	16.488	1.030	13.483	112.635	8.954	25.660	1.561	1.276	102.171
3.755	16.409	1.036	13.313	112.622	9.088	25.403	1.576	1.646	101.987
3.990	16.334	1.041	13.254	112.642	9.223	25.207	1.591	2.119	102.961
4.225	16.264	1.048	13.303	112.696	9.357	25.059	1.606	2.744	104.034
4.459	16.198	1.054	13.462	118.658	9.492	24.947	1.622	3.605	105.163
4.459	0.000	0.000	0.000	0.000	9.626	24.864	1.638	5.063	106.487
4.459	16.198	1.054	15.316	118.810	9.626	0.000	0.000	0.000	0.000
4.694	16.230	1.061	105.698	122.233	9.626	24.864	1.638	0.445	102.282
4.928	16.214	1.069	42.613	122.096	9.764	24.248	1.650	0.759	100.474
5.162	16.194	1.077	37.430	117.226	9.901	23.975	1.663	1.381	101.948
5.397	16.175	1.086	38.231	117.328	10.038	23.772	1.676	1.760	102.690
5.631	16.157	1.095	42.135	120.036	10.175	23.610	1.689	2.135	103.317
5.865	16.143	1.104	49.759	120.956	10.312	23.477	1.702	2.541	103.899
6.099	16.131	1.114	64.314	122.280	10.450	23.366	1.715	2.998	104.466
6.334	16.124	1.124	97.498	124.384	10.587	23.274	1.728	3.529	105.036
6.568	16.119	1.135	231.009	129.447	10.724	23.198	1.742	4.163	105.625
6.802	16.119	1.146	463.408	128.194	10.861	23.133	1.756	4.941	106.248
7.037	16.122	1.157	109.362	125.788	10.998	23.081	1.770	6.014	106.975
7.271	16.128	1.169	60.313	122.914	10.998	0.000	0.000	0.000	0.000
7.505	16.139	1.181	40.943	121.338	10.998	23.081	1.770	0.002	99.077
7.739	16.153	1.193	30.639	120.272	11.027	41.521	1.783	0.017	90.390
7.974	16.170	1.206	24.248	119.527	11.056	35.523	1.796	0.021	98.734
7.974	0.000	0.000	0.000	0.000	11.085	32.749	1.810	0.038	97.884
7.974	34.688	1.369	0.004	95.494	11.114	31.026	1.823	0.054	95.699
8.004	53.840	1.381	0.042	77.326	11.143	29.804	1.836	0.071	96.661

TABLES IV-ABLE CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
11.172	28.867	1.849	0.088	97.375	16.695	28.733	3.409	0.741	97.530
11.201	28.112	1.863	0.104	99.645	16.929	28.274	3.423	0.871	99.840
11.231	27.481	1.876	0.120	100.950	17.164	27.859	3.437	0.926	99.882
11.260	26.941	1.890	0.135	100.098	17.399	27.476	3.451	0.972	100.972
11.289	26.468	1.903	0.153	101.296	17.634	27.120	3.466	1.014	99.903
11.289	0.000	0.000	0.000	0.000	17.869	26.786	3.480	1.053	100.279
11.289	36.427	2.417	0.008	94.669	18.104	26.473	3.495	1.091	101.292
11.345	49.414	2.421	0.059	82.817	18.339	26.178	3.511	1.129	101.343
11.401	44.591	2.424	0.060	87.005	18.573	25.900	3.526	1.166	101.698
11.457	42.143	2.428	0.100	89.578	18.808	25.636	3.542	1.205	102.245
11.513	40.504	2.432	0.136	91.381	18.808	0.000	0.000	0.000	0.000
11.569	39.269	2.435	0.169	92.386	18.808	25.636	3.542	0.513	101.097
11.626	38.275	2.439	0.200	93.184	19.039	25.129	3.554	0.689	103.541
11.682	37.444	2.443	0.229	93.849	19.269	24.787	3.566	0.880	103.411
11.738	36.728	2.446	0.258	94.423	19.499	24.481	3.578	0.945	100.010
11.794	36.099	2.450	0.285	94.909	19.729	24.199	3.590	0.992	100.777
11.850	35.539	2.454	0.315	93.385	19.960	23.934	3.602	1.031	102.107
11.850	0.000	0.000	0.000	0.000	20.190	23.685	3.615	1.065	103.037
11.850	35.539	2.454	2.202	98.867	20.420	23.448	3.628	1.097	104.053
11.960	35.268	2.467	0.810	95.761	20.651	23.223	3.641	1.127	105.438
12.070	34.751	2.479	0.630	95.428	20.881	23.008	3.654	1.156	99.130
12.180	34.278	2.492	0.680	95.899	21.111	22.803	3.667	1.186	107.305
12.290	33.856	2.505	0.745	96.488	21.111	0.000	0.000	0.000	0.000
12.399	33.478	2.518	0.816	97.012	21.111	22.803	3.667	1.025	107.211
12.509	33.140	2.532	0.891	97.411	21.294	22.912	3.681	5.480	106.717
12.619	32.835	2.545	0.969	97.775	21.476	22.872	3.696	3.652	107.872
12.729	32.560	2.559	1.051	98.114	21.658	22.811	3.711	2.812	108.112
12.839	32.310	2.572	1.136	98.434	21.841	22.742	3.726	2.539	105.475
12.949	32.081	2.586	1.233	98.753	22.023	22.669	3.741	2.415	104.548
12.949	0.000	0.000	0.000	0.000	22.206	22.594	3.756	2.352	103.710
12.949	49.091	3.128	0.076	85.987	22.388	22.519	3.772	2.323	103.106
13.095	43.681	3.141	0.131	87.505	22.570	22.444	3.787	2.313	102.999
13.240	41.807	3.154	0.283	89.971	22.753	22.370	3.803	2.316	102.909
13.386	40.482	3.167	0.365	91.400	22.935	22.297	3.819	2.324	102.379
13.532	39.434	3.180	0.434	92.252	22.935	0.000	0.000	0.000	0.000
13.678	38.561	3.193	0.497	92.955	22.935	22.297	3.819	0.254	92.757
13.824	37.810	3.207	0.555	93.556	23.028	22.549	3.830	0.511	103.161
13.969	37.151	3.221	0.610	94.083	23.120	22.633	3.842	1.225	104.161
14.115	36.564	3.235	0.663	94.556	23.213	22.690	3.853	1.732	104.779
14.261	36.035	3.249	0.715	94.964	23.306	22.732	3.865	2.240	105.327
14.407	35.554	3.263	0.772	95.405	23.399	22.766	3.876	2.770	105.863
14.407	0.000	0.000	0.000	0.000	23.491	22.793	3.888	3.331	106.360
14.407	35.554	3.263	0.328	93.367	23.584	22.817	3.900	3.930	108.326
14.612	34.272	3.275	0.447	95.906	23.677	22.836	3.911	4.570	109.036
14.818	33.449	3.288	0.593	97.055	23.769	22.854	3.923	5.255	109.611
15.023	32.743	3.301	0.657	97.890	23.862	22.868	3.935	6.071	110.121
15.228	32.117	3.313	0.710	98.704	23.862	0.000	0.000	0.000	0.000
15.434	31.552	3.327	0.757	95.291	23.862	22.868	3.935	0.014	107.781
15.639	31.036	3.340	0.802	95.691	23.892	24.304	3.948	0.028	100.362
15.844	30.561	3.353	0.844	96.064	23.921	24.901	3.961	0.055	105.931
16.049	30.122	3.367	0.886	96.409	23.951	25.360	3.974	0.070	102.216
16.254	29.714	3.381	0.926	96.733	23.981	25.748	3.987	0.082	101.973
16.460	29.334	3.395	0.969	97.055	24.010	26.091	4.000	0.093	101.437
16.460	0.000	0.000	0.000	0.000	24.040	26.400	4.013	0.103	101.100
16.460	29.334	3.395	0.606	95.460	24.069	26.686	4.026	0.112	100.395

TABLES IV-TABLE CONTINUED, PART 3

PHI	X	H	F	TINS	PHI	X	H	F	TINS
24.099	26.952	4.040	0.121	100.085	26.981	27.648	4.680	0.439	100.327
24.129	27.202	4.053	0.129	99.870	27.046	27.534	4.694	0.621	100.698
24.156	27.438	4.066	0.138	101.396	27.111	27.451	4.708	0.837	101.087
24.156	0.000	0.000	0.000	0.000	27.176	27.389	4.723	1.101	101.776
24.156	27.438	4.066	0.040	101.242	27.241	27.341	4.737	1.430	102.230
24.243	25.793	4.079	0.084	101.868	27.306	27.304	4.751	1.848	102.745
24.328	25.408	4.092	0.278	101.965	27.371	27.276	4.766	2.397	103.338
24.413	25.193	4.105	0.464	103.058	27.436	27.254	4.780	3.257	104.129
24.496	25.054	4.118	0.686	104.087	27.436	0.000	0.000	0.000	0.000
24.583	24.956	4.132	0.954	105.073					
24.666	24.884	4.145	1.276	106.183					
24.753	24.830	4.158	1.667	102.708					
24.836	24.788	4.172	2.143	103.389					
24.924	24.755	4.185	2.730	104.073					
25.009	24.730	4.199	3.585	104.894					
25.009	0.000	0.000	0.000	0.000					
25.009	24.730	4.199	1.245	102.230					
25.102	24.673	4.214	1.958	103.290					
25.195	24.642	4.228	3.125	104.564					
25.289	24.619	4.243	4.034	105.352					
25.382	24.600	4.258	5.092	106.115					
25.475	24.586	4.273	6.400	106.901					
25.569	24.574	4.288	8.088	107.739					
25.662	24.565	4.303	10.368	108.661					
25.755	24.558	4.318	13.631	109.711					
25.849	24.553	4.333	18.702	110.960					
25.942	24.549	4.348	28.646	112.684					
25.942	0.000	0.000	0.000	0.000					
25.942	24.549	4.348	0.050	99.996					
25.989	25.202	4.362	0.093	102.997					
26.037	25.472	4.375	0.181	101.744					
26.085	25.680	4.389	0.227	102.128					
26.132	25.855	4.402	0.265	101.770					
26.180	26.009	4.416	0.298	101.524					
26.227	26.149	4.430	0.327	101.374					
26.275	26.279	4.444	0.354	101.234					
26.322	26.399	4.457	0.378	101.102					
26.370	26.513	4.471	0.401	101.262					
26.417	26.620	4.485	0.424	101.183					
26.417	0.000	0.000	0.000	0.000					
26.417	26.620	4.485	0.043	100.470					
26.454	27.255	4.500	0.075	104.102					
26.491	27.563	4.515	0.127	100.611					
26.528	27.814	4.531	0.152	99.960					
26.565	28.036	4.546	0.170	99.625					
26.602	28.238	4.561	0.186	99.797					
26.638	28.426	4.576	0.200	99.963					
26.675	28.602	4.592	0.213	97.705					
26.712	28.770	4.607	0.225	97.488					
26.749	28.930	4.623	0.236	97.301					
26.786	29.084	4.638	0.247	96.938					
26.786	0.000	0.000	0.000	0.000					
26.786	29.084	4.638	0.048	96.100					
26.851	28.090	4.652	0.099	99.619					
26.916	27.815	4.666	0.281	99.958					

TABLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 13, 1964 1639CST

Y	C	U	V	T	Y	C	U	V	T
0.000	335.717	0.357	336.074	280.450	2604.840	327.562	17.295	344.857	266.990
100.000	334.337	-0.269	334.068	278.150	2658.500	327.457	17.209	344.667	266.821
168.000	334.032	-1.029	333.003	277.643	2731.000	327.291	16.783	344.074	266.550
238.000	333.856	-1.847	332.009	277.350	2804.500	326.935	16.108	343.043	265.971
300.500	333.547	-2.615	330.931	276.836	2878.000	326.554	15.579	342.132	265.350
365.000	333.254	-3.203	330.051	276.350	2941.000	326.315	15.712	342.027	264.962
435.000	333.021	-3.461	329.561	275.965	3004.000	326.123	16.322	342.445	264.650
505.000	332.892	-3.323	329.569	275.750	3062.500	326.000	17.485	343.486	264.452
572.000	332.952	-2.589	330.363	275.851	3121.000	325.876	18.849	344.725	264.250
639.000	333.073	-1.607	331.465	276.050	3192.000	325.631	20.161	345.791	263.852
707.000	333.145	-0.657	332.487	276.169	3263.000	325.382	21.591	346.974	263.450
775.000	333.193	0.248	333.442	276.250	3329.000	325.205	23.359	348.564	263.163
846.500	333.201	0.987	334.188	276.263	3395.000	325.074	25.346	350.420	262.950
922.000	333.193	1.768	334.961	276.250	3468.500	324.962	27.620	352.582	262.770
988.000	333.172	2.816	335.988	276.215	3542.000	324.950	30.061	355.011	262.750
1054.000	333.193	3.900	337.093	276.250	3604.500	325.160	32.466	357.625	263.089
1130.000	333.441	4.933	338.374	276.661	3667.000	325.382	34.845	360.227	263.450
1206.000	333.555	5.797	339.351	276.850	3743.000	325.434	37.291	362.725	263.534
1250.414	333.275	6.242	339.517	276.386	3819.000	325.382	39.509	364.891	263.450
1278.500	333.098	6.353	339.451	276.092	3877.000	325.237	41.126	366.363	263.214
1351.000	332.529	6.784	339.313	275.150	3935.000	325.074	42.379	367.452	262.950
1420.000	332.246	7.138	339.384	274.682	3998.999	325.019	42.875	367.894	262.862
1489.000	332.045	7.566	339.611	274.350	4000.500	325.018	42.876	367.894	262.859
1563.500	331.853	8.306	340.159	274.032	4066.000	324.950	43.349	368.299	262.750
1638.000	331.682	9.186	340.869	273.750	4132.500	324.738	44.707	369.445	262.408
1704.000	331.541	10.119	341.659	273.516	4199.000	324.517	46.289	370.805	262.050
1770.000	331.379	10.976	342.355	273.250	4273.500	324.396	47.921	372.318	261.856
1836.500	331.170	11.476	342.646	272.905	4348.000	324.269	49.423	373.692	261.650
1893.609	330.932	11.766	342.698	272.514	4416.500	324.031	50.526	374.557	261.267
1903.000	330.894	11.803	342.697	272.450	4485.000	323.773	51.444	375.217	260.850
1970.500	330.490	12.098	342.588	271.785					
2038.000	330.042	12.233	342.275	271.050					
2106.500	329.600	11.998	341.597	270.323					
2175.000	329.189	11.791	340.980	269.650					
2249.500	328.827	11.905	340.732	269.057					
2324.000	328.517	12.457	340.974	268.550					
2389.000	328.296	13.785	342.080	268.188					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
FEB 13, 1964 1639CST	45	254	35	7	70

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 13, 1964 1639CST

PHI	XFOCUS	TINF	DXDPHI2
6.771	15.000	106.575	MIN
10.555	22.403	98.403	MIN
12.675	31.799	92.947	MIN
21.937	23.492	105.414	MIN
24.894	27.046	96.757	MIN
25.040	27.073	97.772	MAX
25.520	26.896	94.934	MIN

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES.
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS.
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX.
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS.
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY.
F = DIMENSIONLESS VALUE OF FOCUS FACTOR.
TINS = SOUND INTENSITY IN DB.
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES.
AZIMUTH = 45 DEGREES. DATE-TIME = FEB 13, 1964 1639CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	17.166	0.993	139.023	122.426	8.237	33.880	1.482	0.079	96.082
0.446	16.939	0.993	75.265	119.886	8.259	32.923	1.485	0.101	97.076
0.892	16.715	0.995	38.021	117.059	8.281	32.167	1.489	0.119	98.877
1.338	16.499	0.998	26.080	115.569	8.281	0.000	0.000	0.000	0.000
1.784	16.294	1.002	20.595	114.690	8.281	32.167	1.489	0.119	98.877
2.230	16.104	1.007	17.846	114.207	8.403	29.594	1.507	0.212	97.644
2.676	15.933	1.014	16.709	114.042	8.526	28.134	1.523	0.324	99.370
3.122	15.786	1.022	16.939	114.211	8.648	27.115	1.537	0.423	102.127
3.567	15.667	1.031	19.021	114.802	8.771	26.333	1.551	0.514	99.330
4.013	15.580	1.042	25.461	116.084	8.893	25.697	1.563	0.635	99.799
4.459	15.531	1.054	25.075	116.062	8.893	0.000	0.000	0.000	0.000
4.459	0.000	0.000	0.000	0.000	8.893	25.697	1.564	0.635	99.799
4.459	15.531	1.054	25.075	116.062	9.040	25.155	1.578	0.870	100.671
4.707	15.493	1.061	18.479	114.846	9.186	24.766	1.593	1.143	101.540
4.955	15.443	1.069	14.588	113.947	9.333	24.469	1.608	1.434	102.410
5.202	15.387	1.077	12.674	113.454	9.480	24.235	1.623	1.756	103.338
5.450	15.328	1.085	11.427	113.199	9.626	24.046	1.638	1.578	103.701
5.697	15.266	1.094	10.510	113.051	9.626	0.000	0.000	0.000	0.000
5.945	15.202	1.103	9.794	112.971	9.626	24.046	1.638	1.578	103.701
6.193	15.137	1.112	9.211	112.970	9.777	23.766	1.653	1.214	105.425
6.440	15.071	1.121	8.726	113.790	9.928	23.449	1.667	1.110	99.857
6.688	15.005	1.130	20.806	115.338	10.078	23.132	1.680	1.097	100.262
6.688	0.000	0.000	0.000	0.000	10.229	22.825	1.692	1.107	100.927
6.686	15.005	1.130	20.806	115.338	10.380	22.531	1.704	1.534	103.679
6.945	15.020	1.140	8.226	116.337	10.380	0.000	0.000	0.000	0.000
7.202	15.139	1.152	2.963	112.940	10.380	22.531	1.704	1.534	103.679
7.459	15.383	1.166	1.513	113.430	10.504	22.414	1.714	4.914	105.585
7.717	15.836	1.183	0.740	114.143	10.627	22.425	1.725	3.433	107.714
7.974	16.800	1.206	0.320	118.376	10.751	22.564	1.737	1.117	102.767
7.974	0.000	0.000	0.000	0.000	10.875	22.884	1.752	0.526	100.617
7.974	16.800	1.206	0.320	118.376	10.998	23.541	1.770	0.295	109.554
8.015	17.076	1.211	0.257	121.608	10.998	0.000	0.000	0.000	0.000
8.053	17.451	1.216	0.185	93.520	10.998	23.541	1.770	0.295	109.554
8.092	17.996	1.222	0.116	91.229	11.048	23.932	1.779	0.239	104.139
8.132	18.955	1.230	0.000	62.833	11.097	24.427	1.789	0.182	102.554
8.171	1000.000	1.250	0.000	0.000	11.147	25.116	1.800	0.122	100.756
8.171	0.000	0.000	0.000	0.000	11.196	26.225	1.815	0.060	99.404
8.171	1000.000	1.470	0.000	0.000	11.246	28.955	1.837	0.026	98.300
8.193	37.356	1.474	0.000	92.802	11.246	0.000	0.000	0.000	0.000
8.215	35.194	1.478	0.054	94.785	11.246	28.955	1.837	0.026	98.300

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR

TABLES IV-BRAVO CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
11.254	29.879	1.843	0.023	97.454	15.393	32.120	3.329	0.689	99.045
11.263	30.950	1.849	0.019	95.934	15.606	31.527	3.342	0.746	95.313
11.272	32.387	1.857	0.013	98.008	15.820	30.993	3.355	0.796	95.891
11.281	34.765	1.868	0.000	95.195	16.033	30.504	3.368	0.839	97.007
11.290	1000.000	1.894	0.000	0.000	16.246	30.051	3.382	0.878	97.333
11.290	0.000	0.000	0.000	0.000	16.460	29.629	3.395	0.916	97.618
11.290	1000.000	2.416	0.000	0.000	16.460	0.000	0.000	0.000	0.000
11.402	44.126	2.422	0.001	84.193	16.460	29.629	3.395	0.916	97.618
11.514	40.157	2.429	0.125	91.458	16.690	29.205	3.409	0.958	98.012
11.626	37.955	2.437	0.197	92.356	16.920	28.811	3.424	0.999	98.465
11.736	36.487	2.445	0.274	93.569	17.151	28.443	3.439	1.038	98.952
11.850	35.446	2.454	0.352	94.552	17.381	28.097	3.454	1.075	99.421
11.850	0.000	0.000	0.000	0.000	17.611	27.772	3.469	1.066	99.795
11.850	35.446	2.454	0.352	94.552	17.611	0.000	0.000	0.000	0.000
11.993	34.413	2.466	0.436	95.539	17.611	27.772	3.469	1.066	99.795
12.136	33.591	2.479	0.525	96.366	17.851	27.424	3.484	1.025	100.296
12.279	32.928	2.492	0.625	97.071	18.090	27.077	3.499	1.007	103.580
12.422	32.385	2.506	0.740	98.013	18.329	26.736	3.514	1.002	99.021
12.564	31.937	2.520	1.159	100.438	18.569	26.404	3.528	1.003	99.295
12.564	0.000	0.000	0.000	0.000	18.808	26.082	3.542	0.965	99.521
12.564	31.937	2.520	1.159	100.438	18.808	0.000	0.000	0.000	0.000
12.641	31.812	2.528	3.264	101.789	18.808	26.082	3.542	0.965	99.521
12.718	31.821	2.537	1.876	103.301	19.047	25.742	3.556	0.910	99.757
12.795	32.013	2.548	0.498	99.420	19.286	25.399	3.569	0.887	100.269
12.872	32.580	2.562	0.125	97.483	19.525	25.060	3.581	0.879	100.884
12.949	35.064	2.586	0.025	94.899	19.764	24.729	3.593	0.878	101.638
12.949	0.000	0.000	0.000	0.000	20.003	24.406	3.605	0.957	102.623
12.949	35.064	2.586	0.025	94.899	20.003	0.000	0.000	0.000	0.000
12.952	35.441	2.588	0.021	94.557	20.003	24.406	3.604	0.957	102.623
12.955	35.920	2.590	0.016	94.112	20.224	24.162	3.615	1.158	103.414
12.959	36.591	2.593	0.010	93.481	20.446	23.968	3.627	1.435	103.937
12.962	37.736	2.596	0.000	92.513	20.668	23.815	3.639	1.836	105.001
12.966	1000.000	2.605	0.000	0.000	20.890	23.702	3.653	2.657	106.054
12.966	0.000	0.000	0.000	0.000	21.111	23.634	3.667	3.745	107.291
12.966	1000.000	3.129	0.000	0.000	21.111	0.000	0.000	0.000	0.000
13.097	45.748	3.140	0.001	66.330	21.111	23.634	3.667	3.745	107.291
13.226	43.240	3.151	0.211	86.767	21.311	23.581	3.681	4.290	108.278
13.360	41.749	3.164	0.320	89.238	21.511	23.536	3.695	5.491	109.827
13.491	40.718	3.177	0.440	90.874	21.711	23.505	3.710	9.435	112.661
13.622	39.981	3.192	0.498	91.633	21.911	23.492	3.726	77.250	117.221
13.622	0.000	0.000	0.000	0.000	22.111	23.500	3.743	20.548	115.973
13.622	39.981	3.192	0.498	91.633	22.111	0.000	0.000	0.000	0.000
13.779	39.043	3.209	0.467	91.833	22.111	23.500	3.743	20.548	115.973
13.936	38.112	3.224	0.469	92.262	22.276	23.509	3.757	13.573	112.039
14.093	37.249	3.238	0.489	92.897	22.441	23.524	3.772	8.937	110.648
14.250	36.452	3.251	0.513	93.603	22.606	23.546	3.787	6.180	109.327
14.407	35.715	3.263	0.538	94.302	22.770	23.576	3.803	4.514	108.385
14.407	0.000	0.000	0.000	0.000	22.935	23.617	3.819	3.232	107.560
14.407	35.715	3.263	0.538	94.302	22.935	0.000	0.000	0.000	0.000
14.604	34.870	3.277	0.571	95.092	22.935	23.617	3.819	3.232	107.560
14.801	34.101	3.291	0.601	95.862	23.043	23.654	3.830	2.499	106.888
14.998	33.392	3.304	0.628	96.584	23.150	23.701	3.841	2.005	106.070
15.196	32.734	3.317	0.652	97.297	23.258	23.757	3.853	1.692	105.506
15.393	32.120	3.329	0.689	99.045	23.366	23.824	3.865	1.448	104.957
15.393	0.000	0.000	0.000	0.000	23.473	23.901	3.877	0.921	104.309

TABLES IV-BRAVO CONTINUED, PART 3

PHI	X	H	F	TINS	PHI	X	H	F	TINS
23.473	0.000	0.000	0.000	0.000	26.213	29.275	4.417	0.115	97.932
23.473	23.901	3.877	0.921	104.309	26.213	0.000	0.000	0.000	0.000
23.551	24.000	3.886	0.593	103.796	26.213	29.275	4.417	0.115	97.932
23.629	24.152	3.897	0.411	103.431	26.254	29.626	4.430	0.132	97.620
23.707	24.364	3.908	0.297	102.798	26.295	29.923	4.443	0.151	97.426
23.784	24.659	3.920	0.209	101.844	26.335	30.197	4.457	0.163	97.230
23.862	25.091	3.935	0.132	100.811	26.376	30.457	4.471	0.171	97.041
23.862	0.000	0.000	0.000	0.000	26.417	30.708	4.485	0.179	96.854
23.862	25.091	3.935	0.132	100.811	26.417	0.000	0.000	0.000	0.000
23.893	25.347	3.942	0.102	100.353					
23.924	25.699	3.949	0.072	99.797					
23.955	26.217	3.958	0.044	99.410					
23.986	27.137	3.970	0.000	101.877					
24.017	1000.000	3.999	0.000	0.000					
24.017	0.000	0.000	0.000	0.000					
24.017	1000.000	4.004	0.000	0.000					
24.045	31.723	4.031	0.000	95.090					
24.074	30.728	4.043	0.043	96.155					
24.102	30.131	4.052	0.064	97.276					
24.130	29.697	4.059	0.084	97.572					
24.158	29.354	4.066	0.103	97.853					
24.158	0.000	0.000	0.000	0.000					
24.158	29.354	4.066	0.103	97.853					
24.237	28.725	4.082	0.165	98.568					
24.316	28.291	4.097	0.220	99.157					
24.395	27.944	4.110	0.263	99.595					
24.473	27.648	4.122	0.300	99.927					
24.552	27.387	4.132	0.384	100.365					
24.552	0.000	0.000	0.000	0.000					
24.552	27.387	4.133	0.384	100.365					
24.643	27.201	4.145	0.664	101.163					
24.735	27.102	4.158	1.286	102.278					
24.826	27.055	4.171	3.387	110.165					
24.917	27.047	4.185	11.092	109.370					
25.009	27.072	4.199	9.242	108.497					
25.009	0.000	0.000	0.000	0.000					
25.009	27.072	4.199	9.242	108.497					
25.107	27.065	4.214	5.371	110.079					
25.206	27.035	4.230	2.773	104.024					
25.305	26.994	4.244	2.259	103.669					
25.404	26.947	4.259	2.027	103.974					
25.503	26.897	4.274	7.545	106.658					
25.503	0.000	0.000	0.000	0.000					
25.503	26.897	4.274	7.545	106.658					
25.591	26.915	4.287	1.744	106.544					
25.679	26.996	4.300	0.803	103.670					
25.766	27.129	4.315	0.530	101.962					
25.854	27.320	4.331	0.381	100.633					
25.942	27.582	4.348	0.283	100.024					
25.942	0.000	0.000	0.000	0.000					
25.942	27.582	4.348	0.283	100.024					
25.996	27.789	4.360	0.234	99.773					
26.050	28.043	4.372	0.191	99.480					
26.105	28.356	4.385	0.154	99.067					
26.159	28.753	4.400	0.121	98.531					

TABLES I-ABLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 27,1964 1636CST

Y	C	U	V	T	Y	C	U	V	T
0.000	334.698	-3.088	331.609	278.750					
100.000	333.434	-0.864	332.570	276.650					
230.000	332.529	-2.899	329.630	275.150					
350.000	332.469	-2.909	329.560	275.050					
484.000	332.529	-0.204	332.325	275.150					
610.000	332.892	3.820	336.712	275.750					
770.000	334.277	7.994	342.271	278.050					
894.000	333.555	9.664	343.219	276.850					
1031.000	333.374	8.979	342.354	276.550					
1152.000	333.133	8.451	341.584	276.150					
1265.000	332.650	8.412	341.062	275.350					
1390.000	332.106	8.377	340.483	274.450					
1514.000	331.682	8.076	339.758	273.750					
1661.000	330.894	7.505	338.399	272.450					
1789.000	330.408	7.119	337.527	271.650					
1920.000	329.738	7.000	336.738	270.550					
2062.000	329.067	6.760	335.827	269.450					
2190.000	328.517	5.963	334.479	268.550					
2310.000	327.721	5.658	333.379	267.250					
2458.000	326.984	5.733	332.717	266.050					
2597.000	326.369	5.902	332.271	265.050					
2726.000	326.184	7.532	333.716	264.750					
2872.000	326.061	9.613	335.674	264.550					
3030.000	326.061	11.071	337.132	264.550					
3150.000	325.382	12.313	337.696	263.450					
3290.000	325.135	13.879	339.015	263.050					
3449.000	324.455	15.599	340.053	261.950					
3593.000	323.649	17.053	340.702	260.650					
3727.000	323.400	18.574	341.975	260.250					
3876.000	322.841	21.327	344.168	259.350					
3989.000	322.778	25.597	348.376	259.250					
4142.000	322.218	30.256	352.474	258.350					
4325.000	322.218	33.862	356.080	258.350					
4471.000	321.406	36.092	357.498	257.050					
4600.000	321.218	38.003	359.222	256.750					
4757.000	320.592	40.776	361.368	255.750					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
FEB 27,1964 1636CST	45	158	11	3	36

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 27,1964 1636CST

PHI	XFOCUS	TINF	DXDPHI2
12.252	8.258	117.064	MIN
19.925	29.988	96.695	MAX
22.210	31.305	100.387	MIN

TABLES IV-ABLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES.
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS.
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX.
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS.
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY.
F = DIMENSIONLESS VALUE OF FOCUS FACTOR.
TINS = SOUND INTENSITY IN DB.
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES.
AZIMUTH = 45 DEGREES. DATE-TIME = FEB 27.1964 1636CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	0.000	1.000	0.000	9.942	8.456	0.616	6.971	115.582
0.241	0.313	0.000	1.000	135.774	9.942	0.000	0.000	0.000	0.000
0.482	0.626	0.001	1.000	129.754	9.942	8.456	0.616	2.882	111.764
0.723	0.938	0.003	1.000	126.233	10.183	8.397	0.623	4.161	113.409
0.964	1.251	0.005	1.000	123.735	10.423	8.362	0.631	5.965	115.004
1.204	1.564	0.008	1.000	121.798	10.664	8.333	0.638	7.259	119.016
1.445	1.876	0.012	1.000	120.216	10.905	8.310	0.646	8.846	119.850
1.686	2.189	0.016	1.001	118.879	11.145	8.292	0.654	11.033	120.830
1.927	2.501	0.021	1.001	117.721	11.386	8.278	0.663	14.373	122.003
2.168	2.813	0.026	1.001	116.700	11.627	8.268	0.671	20.230	123.524
2.409	3.126	0.033	1.001	115.787	11.867	8.262	0.680	33.340	125.782
2.650	3.437	0.040	1.001	114.962	12.108	8.258	0.688	89.871	130.713
2.891	3.749	0.047	1.002	114.209	12.349	8.258	0.697	137.989	128.741
3.131	4.061	0.055	1.002	113.517	12.589	8.261	0.706	39.712	126.907
3.372	4.372	0.064	1.002	112.877	12.830	8.266	0.716	23.412	124.178
3.613	4.683	0.074	1.003	112.282	13.071	8.274	0.725	16.704	122.615
3.854	4.994	0.084	1.003	111.725	13.311	8.284	0.735	13.044	121.484
4.095	5.305	0.095	1.003	111.203	13.552	8.296	0.745	10.739	120.586
4.335	5.615	0.106	1.004	110.710	13.793	8.311	0.755	9.154	119.835
4.336	0.000	0.000	0.000	0.000	14.033	8.327	0.765	7.998	119.222
4.336	14.975	0.491	0.297	96.908	14.274	8.346	0.776	7.099	118.646
4.616	12.534	0.495	0.465	101.838	14.274	0.000	0.000	0.000	0.000
4.896	11.703	0.499	0.960	104.731	14.274	8.346	0.776	0.018	115.517
5.177	11.142	0.504	1.203	105.935	14.334	9.822	0.788	0.039	108.715
5.457	10.708	0.508	1.400	106.823	14.395	10.438	0.799	0.079	107.387
5.737	10.358	0.513	1.575	107.545	14.455	10.913	0.811	0.102	106.411
6.016	10.068	0.518	1.739	108.161	14.515	11.315	0.823	0.121	105.578
6.296	9.821	0.524	1.901	108.716	14.576	11.671	0.834	0.139	104.813
6.576	9.610	0.529	2.066	109.253	14.636	11.995	0.846	0.156	103.851
6.859	9.426	0.535	2.238	109.757	14.696	12.293	0.858	0.171	102.810
7.139	9.267	0.541	2.423	110.240	14.757	12.572	0.870	0.185	101.807
7.419	9.128	0.547	2.624	110.710	14.817	12.836	0.882	0.199	101.598
7.700	9.006	0.554	2.847	111.175	14.878	13.085	0.894	0.213	101.410
7.980	8.899	0.561	3.098	111.642	14.878	0.000	0.000	0.000	0.000
8.260	8.805	0.568	3.387	112.115	14.878	55.988	3.812	0.040	76.753
8.540	8.723	0.575	3.723	112.603	14.935	51.947	3.818	0.071	79.873
8.821	8.652	0.583	4.120	113.110	14.993	50.435	3.824	0.146	83.257
9.101	8.591	0.591	4.599	113.647	15.051	49.334	3.831	0.186	84.516
9.381	8.538	0.599	5.189	114.222	15.109	48.444	3.837	0.220	85.403
9.662	8.494	0.607	5.936	114.848	15.167	47.688	3.843	0.250	86.101

PHI		H	F	TINS	PHI	X	H	F	TINS
15.225	47.025	3.850	0.278	86.681	21.911	31.432	4.484	0.452	98.711
15.285	46.434	3.856	0.305	87.180	21.978	31.361	4.498	1.746	100.884
15.345	45.838	3.863	0.329	87.621	22.045	31.328	4.511	3.713	107.421
15.395	45.405	3.869	0.353	88.015	22.112	31.312	4.524	5.358	109.781
15.456	44.954	3.876	0.378	88.402	22.179	31.306	4.538	31.668	111.056
15.456	0.000	0.000	0.000	0.000	22.246	31.306	4.551	39.764	114.382
15.456	44.954	3.876	0.201	85.657	22.313	31.311	4.565	15.666	110.767
15.687	42.199	3.886	0.270	87.490	22.380	31.318	4.579	10.953	108.710
15.919	40.464	3.897	0.364	89.145	22.447	31.327	4.592	8.976	107.521
16.156	38.049	3.908	0.415	90.032	22.514	31.338	4.606	7.776	106.698
16.381	37.842	3.919	0.459	90.742	22.514	0.000	0.000	0.000	0.000
16.615	36.786	3.930	0.499	91.347	22.514	31.338	4.606	0.521	102.884
16.844	35.847	3.942	0.535	91.878	22.594	31.184	4.621	1.009	99.734
17.075	35.001	3.953	0.569	92.353	22.674	31.130	4.636	2.268	101.520
17.306	34.231	3.965	0.601	92.785	22.754	31.093	4.651	3.138	102.434
17.536	33.526	3.977	0.632	93.181	22.834	31.064	4.666	4.015	103.198
17.769	32.876	3.989	0.665	93.574	22.914	31.041	4.681	4.949	103.887
17.769	0.000	0.000	0.000	0.000	22.994	31.022	4.696	5.970	104.535
17.769	32.876	3.989	2.636	99.553	23.074	31.007	4.711	7.110	105.160
17.965	32.670	4.003	1.226	96.284	23.154	30.994	4.726	8.404	105.776
18.166	32.315	4.018	0.947	95.257	23.234	30.983	4.742	9.899	106.393
18.356	31.959	4.033	0.937	95.305	23.314	30.974	4.757	11.830	107.080
18.552	31.613	4.048	0.947	98.478	23.314	0.000	0.000	0.000	0.000
18.747	31.280	4.063	0.965	99.191					
18.943	30.960	4.079	0.986	97.345					
19.139	30.655	4.094	1.010	97.208					
19.334	30.363	4.110	1.034	97.058					
19.536	30.083	4.126	1.060	96.859					
19.726	29.816	4.142	1.088	102.043					
19.726	0.000	0.000	0.000	0.000					
19.726	29.816	4.142	0.843	101.757					
19.886	29.979	4.160	3.749	103.081					
20.036	29.935	4.177	3.842	105.192					
20.190	29.864	4.195	2.826	103.746					
20.344	29.780	4.213	2.520	100.393					
20.499	29.692	4.231	2.386	100.182					
20.653	29.601	4.250	2.324	100.086					
20.806	29.509	4.268	2.298	100.054					
20.963	29.416	4.287	2.294	100.063					
21.117	29.329	4.306	2.306	100.098					
21.272	29.241	4.325	2.323	100.022					
21.272	0.000	0.000	0.000	0.000					
21.272	29.241	4.325	0.067	84.606					
21.329	30.102	4.339	0.128	96.853					
21.386	30.440	4.354	0.262	97.118					
21.443	30.693	4.368	0.338	97.225					
21.501	30.902	4.383	0.402	97.318					
21.558	31.083	4.397	0.459	102.701					
21.615	31.244	4.412	0.513	99.400					
21.672	31.390	4.427	0.562	100.115					
21.729	31.524	4.441	0.610	98.592					
21.786	31.649	4.456	0.654	98.433					
21.844	31.766	4.471	0.701	97.798					
21.844	0.000	0.000	0.000	0.000					
21.844	31.766	4.471	0.199	96.217					

TABLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 27,1964 1636CST

Y	C	U	V	T	Y	C	U	V	T
0.000	334.698	-3.088	331.609	278.750	2527.500	326.646	5.716	332.363	265.500
80.186	333.742	-1.061	332.681	277.161	2597.000	326.369	5.902	332.271	265.050
106.000	333.434	-0.864	332.570	276.650	2662.500	326.246	6.605	332.852	264.851
166.000	332.896	-1.742	331.153	275.757	2728.000	326.184	7.532	333.716	264.750
230.000	332.529	-2.899	329.630	275.150	2800.000	326.110	8.604	334.714	264.629
293.000	332.438	-3.200	329.238	274.999	2872.000	326.061	9.613	335.674	264.550
356.000	332.469	-2.909	329.560	275.050	2951.000	326.100	10.386	336.486	264.614
420.000	332.473	-1.801	330.672	275.057	3030.000	326.061	11.071	337.132	264.550
484.000	332.529	-0.204	332.325	275.150	3093.000	325.739	11.675	337.414	264.028
550.000	332.638	1.772	334.410	275.331	3156.000	325.382	12.313	337.696	263.450
616.000	332.892	3.820	336.712	275.750	3226.000	325.253	13.085	338.338	263.241
696.000	333.656	6.049	339.705	277.018	3296.000	325.135	13.879	339.015	263.050
776.000	334.277	7.994	342.271	278.050	3372.500	324.830	14.749	339.579	262.557
835.000	334.003	9.082	343.085	277.595	3449.000	324.455	15.599	340.053	261.950
894.000	333.555	9.664	343.219	276.850	3521.000	324.030	16.325	340.355	261.264
896.223	333.551	9.668	343.219	276.843	3593.000	323.649	17.053	340.702	260.650
962.500	333.432	9.468	342.900	276.646	3660.000	323.509	17.740	341.249	260.425
1031.000	333.374	8.979	342.354	276.550	3727.000	323.400	18.574	341.975	260.250
1091.500	333.276	8.681	341.956	276.387	3801.500	323.111	19.733	342.844	259.785
1152.000	333.133	8.451	341.584	276.150	3876.000	322.841	21.327	344.168	259.350
1206.500	332.907	8.402	341.308	275.775	3932.500	322.809	23.367	346.176	259.299
1260.000	332.650	8.412	341.062	275.350	3989.000	322.778	25.597	348.376	259.250
1331.500	332.373	8.412	340.785	274.892	4065.500	322.485	28.098	350.583	258.779
1398.000	332.106	8.377	340.483	274.450	4142.000	322.218	30.256	352.474	258.350
1456.000	331.905	8.255	340.159	274.117	4233.500	322.236	32.216	354.452	258.379
1514.000	331.682	8.076	339.758	273.750	4325.000	322.218	33.862	356.080	258.350
1587.500	331.288	7.794	339.082	273.100	4398.000	321.832	35.032	356.864	257.731
1661.000	330.894	7.505	338.399	272.450	4471.000	321.406	36.092	357.498	257.050
1725.000	330.648	7.288	337.936	272.045					
1789.000	330.408	7.119	337.527	271.650					
1854.500	330.080	7.049	337.129	271.112					
1920.000	329.738	7.000	336.738	270.550					
1991.000	329.394	6.923	336.317	269.986					
2062.000	329.067	6.760	335.827	269.450					
2129.000	328.809	6.373	335.182	269.027					
2196.000	328.517	5.963	334.479	268.550					
2253.000	328.125	5.760	333.884	267.909					
2310.000	327.721	5.658	333.379	267.250					
2384.000	327.331	5.663	332.995	266.615					
2458.000	327.984	5.733	332.717	266.050					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
FEB 27,1964 1636CST	45	141	17	3	68

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = FEB 27,1964 1636CST

PHI	XFOCUS	TINF	DXDPHI2
12.605	8.017	110.411	MIN
20.643	31.439	98.984	MIN
21.705	34.979	90.566	MAX

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENTIH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = FEB 27,1964 1636CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	0.000	0.998	0.000	10.956	8.227	0.647	5.023	115.368
0.456	0.199	0.000	0.990	139.661	11.209	8.190	0.655	5.000	115.529
0.916	0.402	0.002	0.969	133.458	11.463	8.154	0.663	5.007	115.717
1.374	0.614	0.004	0.933	129.619	11.716	8.119	0.671	5.032	115.926
1.832	0.840	0.007	0.882	126.647	11.970	8.085	0.680	5.070	116.361
2.289	1.090	0.011	0.814	124.038	12.223	8.052	0.688	5.118	117.051
2.747	1.376	0.016	0.725	121.511	12.477	8.021	0.696	10.109	117.643
3.205	1.722	0.023	0.609	118.807	12.477	0.000	0.000	0.000	0.000
3.663	2.183	0.032	0.452	115.456	12.477	8.021	0.696	10.109	117.643
4.121	2.927	0.045	0.001	84.487	12.734	8.021	0.705	8.935	120.392
4.579	1000.000	0.080	0.000	0.000	12.990	8.057	0.714	3.109	116.707
4.579	0.000	0.000	0.000	0.000	13.247	8.122	0.724	1.894	115.892
4.579	1000.000	0.497	0.000	0.000	13.504	8.220	0.735	1.295	115.386
4.860	13.508	0.501	0.002	85.853	13.760	8.359	0.747	0.920	115.738
5.141	12.163	0.506	0.624	102.073	14.017	8.552	0.760	0.654	113.647
5.421	11.386	0.511	0.889	104.205	14.274	8.828	0.776	0.412	111.626
5.702	10.840	0.516	1.103	105.573	14.274	0.000	0.000	0.000	0.000
5.983	10.421	0.521	1.285	106.580	14.274	8.828	0.776	0.412	111.626
6.264	10.082	0.527	1.444	107.414	14.378	8.998	0.783	0.311	110.673
6.545	9.797	0.532	1.585	108.152	14.482	9.238	0.791	0.219	109.658
6.825	9.553	0.538	1.711	108.773	14.586	9.592	0.801	0.140	108.672
7.106	9.340	0.544	1.827	109.334	14.690	10.197	0.813	0.054	107.108
7.387	9.151	0.550	1.987	109.953	14.794	12.205	0.835	0.019	101.904
7.387	0.000	0.000	0.000	0.000	14.794	0.000	0.000	0.000	0.000
7.387	9.151	0.550	1.987	109.953	14.794	12.205	0.835	0.019	101.904
7.646	9.005	0.556	2.227	110.632	14.811	12.985	0.842	0.018	97.595
7.896	8.883	0.561	2.506	111.313	14.828	13.808	0.849	0.016	85.523
8.153	8.777	0.567	2.788	111.926	14.844	14.860	0.858	0.012	83.750
8.409	8.687	0.574	3.115	112.529	14.861	16.537	0.870	0.004	78.975
8.664	8.609	0.580	3.507	113.122	14.878	24.849	0.894	0.000	71.678
8.920	8.543	0.587	3.994	113.733	14.878	0.000	0.000	0.000	0.000
9.175	8.487	0.594	4.619	114.399	14.878	24.849	0.894	0.000	71.678
9.431	8.442	0.601	5.460	115.122	14.878	25.129	0.894	0.000	71.500
9.686	8.404	0.608	6.659	115.951	14.878	25.529	0.895	0.000	71.240
9.942	8.376	0.616	6.631	115.987	14.878	26.121	0.895	0.000	70.931
9.942	0.000	0.000	0.000	0.000	14.878	27.167	0.895	0.000	70.404
9.942	8.376	0.616	6.631	115.987	14.878	1000.000	0.896	0.000	0.000
10.195	8.340	0.624	5.659	115.471	14.878	0.000	0.000	0.000	0.000
10.449	8.303	0.632	5.274	115.320	14.878	1000.000	3.829	0.000	0.000
10.702	8.265	0.639	5.095	115.308	14.993	54.949	3.840	0.001	65.654

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR (H=400.). THE RAY ZENITH FALLS OUTSIDE TOPPING-OUT LAYER (H=600.). OTHER POSSIBLE FAILURES COMPARE ZENITH AND MAX-MIN VALUES OF V RESPECTIVELY, AS FOLLOWS. AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN FOR A MIN OR LESS-THAN FOR A MAX (H=500.).

TABLES IV-GRAVO CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
15.109	51.792	3.850	0.148	83.171	21.641	34.894	4.416	0.292	98.210
15.225	49.728	3.859	0.202	84.838	21.691	34.975	4.432	2.720	100.265
15.341	48.131	3.868	0.242	85.911	21.742	34.951	4.446	1.662	101.314
15.456	46.802	3.876	0.271	86.635	21.793	34.881	4.459	0.952	97.949
15.456	0.000	0.000	0.000	0.000	21.844	34.789	4.471	0.737	97.447
15.456	46.802	3.876	0.271	86.635	21.844	0.000	0.000	0.000	0.000
15.686	44.554	3.890	0.310	87.652					
15.916	42.699	3.902	0.350	88.539					
16.146	41.120	3.913	0.385	89.283					
16.376	39.741	3.923	0.417	89.918					
16.606	38.515	3.932	0.457	90.591					
16.606	0.000	0.000	0.000	0.000					
16.606	38.515	3.932	0.457	90.591					
16.836	37.463	3.942	0.516	91.354					
17.071	36.568	3.952	0.581	92.076					
17.304	35.799	3.963	0.656	92.787					
17.536	35.146	3.975	0.762	93.593					
17.769	34.613	3.989	0.859	95.088					
17.769	0.000	0.000	0.000	0.000					
17.769	34.613	3.989	0.859	95.088					
17.986	34.157	4.003	0.903	95.100					
18.202	33.731	4.017	0.957	95.417					
18.419	33.345	4.033	1.038	95.823					
18.636	33.001	4.049	1.147	96.440					
18.853	32.699	4.066	1.268	97.031					
18.853	0.000	0.000	0.000	0.000					
18.853	32.699	4.065	1.268	97.031					
19.027	32.480	4.080	1.378	97.558					
19.202	32.283	4.094	1.523	98.133					
19.377	32.109	4.110	1.719	98.825					
19.551	31.959	4.125	2.001	99.689					
19.726	31.835	4.142	2.284	100.565					
19.726	0.000	0.000	0.000	0.000					
19.726	31.835	4.142	2.284	100.565					
19.899	31.723	4.159	2.537	101.336					
20.072	31.626	4.177	2.947	102.231					
20.245	31.546	4.195	3.631	103.378					
20.418	31.484	4.214	4.910	105.105					
20.591	31.441	4.233	16.011	107.775					
20.591	0.000	0.000	0.000	0.000					
20.591	31.441	4.233	16.011	107.775					
20.726	31.445	4.250	8.073	109.360					
20.864	31.490	4.267	3.011	104.629					
21.006	31.576	4.285	1.795	102.830					
21.136	31.708	4.304	1.206	101.465					
21.272	31.899	4.325	0.647	100.058					
21.272	0.000	0.000	0.000	0.000					
21.272	31.899	4.325	0.647	100.058					
21.336	32.063	4.336	0.431	99.059					
21.399	32.322	4.347	0.286	98.002					
21.463	32.705	4.361	0.187	97.019					
21.526	33.307	4.377	0.108	95.876					
21.590	34.442	4.398	0.118	94.920					
21.590	0.000	0.000	0.000	0.000					
21.590	34.442	4.398	0.118	94.920					

TAPLES I-ALLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 13,1964 1633CST

Y	C	U	V	T	Y	C	U	V	T
0.000	343.526	0.444	343.971	293.650					
185.000	342.648	1.809	344.457	292.150					
379.000	341.649	3.747	345.396	290.450					
539.000	340.766	4.944	345.710	288.950					
720.000	339.821	6.826	346.647	287.350					
886.000	338.874	8.245	347.119	285.750					
1064.000	337.221	10.035	348.256	284.650					
1245.000	337.086	12.347	350.033	283.750					
1410.000	336.912	14.138	351.050	282.450					
1598.000	336.673	15.727	352.400	282.050					
1779.000	336.016	15.988	352.004	280.950					
1912.000	335.477	16.026	351.503	280.050					
2047.000	334.698	16.125	350.823	278.750					
2195.000	334.938	15.875	350.812	279.150					
2345.000	334.698	16.404	351.102	278.750					
2487.000	334.217	17.364	351.581	277.950					
2609.000	333.856	18.804	352.660	277.350					
2743.000	333.374	19.891	353.266	276.550					
2903.000	333.314	20.465	353.778	276.450					
3030.000	332.831	21.092	353.923	275.650					
3171.000	332.408	21.525	353.933	274.950					
3325.000	331.500	21.503	353.004	273.450					
3481.000	330.529	21.566	352.095	271.850					
3628.000	329.555	21.421	350.976	270.250					
3765.000	329.128	20.379	349.507	269.550					
3929.000	329.677	18.355	348.032	270.450					
4045.000	328.823	16.927	345.749	269.050					
4175.000	328.272	16.821	345.093	268.150					
4333.000	327.230	16.796	344.026	266.450					
4446.000	327.046	16.535	343.580	266.150					
4562.000	326.431	15.888	342.319	265.150					
4685.000	326.246	15.092	341.338	264.850					
4810.000	325.829	15.005	340.835	263.850					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
MARCH 13,1964 1633CST	45	171	14	8	33

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,
AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 13,1964 1633CST

PHI	XFOCUS	TINF	DXDPHI2
5.278	38.009	79.991	MAX
7.203	39.560	79.979	MAX
11.672	23.622	96.674	MIN
12.589	77.138	67.478	MAX
12.761	51.788	84.240	MAX
13.223	65.389	73.108	MAX
13.543	75.323	63.586	MAX
13.629	177.863	40.499	MAX

TABLES IV-AIBLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 13,1964 1633CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	0.000	1.000	0.000	5.892	18.792	0.555	0.486	102.444
0.234	90.618	0.001	1.500	88.304	6.029	18.999	0.572	2.620	105.908
0.468	45.308	0.004	0.750	92.085	6.167	19.122	0.589	3.554	106.802
0.703	30.205	0.010	0.889	96.413	6.304	19.238	0.607	3.451	106.651
0.937	22.653	0.017	0.937	107.008	6.442	19.364	0.625	3.096	106.243
1.171	18.121	0.027	0.960	102.476	6.579	19.504	0.643	2.769	105.829
1.405	15.100	0.039	0.972	102.000	6.717	19.657	0.662	2.510	105.460
1.640	12.942	0.054	0.979	106.923	6.854	19.823	0.681	2.309	105.138
1.874	11.323	0.070	0.983	107.843	6.992	20.000	0.700	2.153	104.853
2.108	10.064	0.089	0.986	108.036	7.129	20.186	0.720	2.022	104.589
2.342	9.057	0.109	0.988	107.811	7.129	0.000	0.000	0.000	0.000
2.577	8.232	0.132	0.990	108.387	7.129	20.186	0.720	0.005	100.197
2.811	7.545	0.158	0.991	108.920	7.189	38.880	0.736	0.055	93.250
3.045	6.964	0.185	1.013	108.877	7.249	31.988	0.752	0.052	95.805
3.045	0.000	0.000	0.000	0.000	7.309	28.690	0.768	0.086	96.956
3.045	6.964	0.185	0.155	100.730	7.368	26.586	0.785	0.118	97.829
3.262	9.374	0.200	0.381	107.605	7.428	25.060	0.801	0.148	98.522
3.479	10.227	0.216	0.844	108.111	7.488	23.870	0.818	0.175	103.430
3.695	10.880	0.232	1.041	108.013	7.548	22.897	0.835	0.201	101.626
3.911	11.451	0.250	1.151	107.796	7.608	22.075	0.852	0.225	103.211
4.128	11.980	0.269	1.210	107.519	7.668	21.364	0.869	0.248	104.329
4.344	12.487	0.289	1.240	107.215	7.727	20.737	0.886	0.273	109.390
4.561	12.982	0.310	1.252	106.898	7.727	0.000	0.000	0.000	0.000
4.777	13.470	0.332	1.253	106.577	7.727	20.737	0.886	0.162	109.342
4.994	13.954	0.355	1.249	106.259	7.855	22.190	0.903	0.446	103.209
5.210	14.436	0.379	1.243	105.948	7.983	22.345	0.919	3.445	106.326
5.210	0.000	0.000	0.000	0.000	8.110	22.396	0.936	8.552	109.052
5.210	14.436	0.379	0.004	102.394	8.238	22.427	0.954	11.201	109.984
5.264	37.108	0.394	0.052	94.206	8.365	22.458	0.971	9.678	109.455
5.317	29.205	0.410	0.052	96.734	8.493	22.497	0.989	7.619	108.624
5.371	25.591	0.425	0.087	98.273	8.621	22.546	1.008	6.119	107.897
5.426	23.295	0.441	0.118	101.638	8.748	22.605	1.026	5.101	107.318
5.482	21.660	0.457	0.148	103.378	8.876	22.674	1.045	4.394	106.857
5.538	20.404	0.473	0.176	100.083	9.003	22.753	1.064	3.867	106.245
5.594	19.392	0.489	0.203	106.162	9.003	0.000	0.000	0.000	0.000
5.649	18.549	0.506	0.228	102.455	9.003	22.753	1.064	0.317	102.240
5.705	17.828	0.522	0.252	102.488	9.172	21.751	1.081	0.589	103.119
5.754	17.200	0.539	0.279	101.946	9.340	21.410	1.098	1.351	104.171
5.754	0.000	0.000	0.000	0.000	9.508	21.185	1.115	1.924	104.905
5.754	17.200	0.539	0.179	101.586	9.676	21.024	1.133	2.592	105.641

TABLES IV-TABLE CONTINUED, PART 2

PHI		H	F	TINS	PHI	X	H	F	TINS
9.844	20.906	1.150	3.458	106.448	13.181	48.011	2.743	0.004	91.656
10.013	20.819	1.169	4.690	107.390	13.216	64.864	2.759	0.034	90.027
10.181	20.758	1.187	6.650	108.564	13.251	57.988	2.775	0.029	90.770
10.349	20.717	1.206	10.352	110.010	13.286	54.535	2.791	0.049	91.299
10.517	20.694	1.225	20.196	112.682	13.321	52.235	2.806	0.067	91.519
10.685	20.685	1.245	218.609	122.787	13.356	50.502	2.822	0.083	92.544
10.685	0.000	0.000	0.000	0.000	13.391	49.102	2.838	0.098	93.240
10.685	20.685	1.245	0.133	100.419	13.426	47.922	2.855	0.111	91.649
10.770	21.629	1.261	0.251	103.462	13.461	46.897	2.871	0.124	91.814
10.858	22.026	1.277	0.481	103.212	13.496	45.989	2.887	0.136	91.960
10.946	22.335	1.293	0.594	106.187	13.531	45.170	2.903	0.148	92.125
11.025	22.601	1.309	0.680	107.363	13.531	0.000	0.000	0.000	0.000
11.109	22.840	1.326	0.749	101.622	13.531	45.170	2.903	0.001	91.346
11.194	23.060	1.342	0.807	101.637	13.541	73.978	2.916	0.005	89.276
11.279	23.267	1.359	0.855	101.639	13.551	65.266	2.928	0.007	89.863
11.364	23.464	1.376	0.896	101.632	13.560	61.295	2.941	0.013	90.442
11.448	23.653	1.393	0.932	107.082	13.570	58.850	2.954	0.020	90.676
11.533	23.835	1.410	0.965	104.598	13.580	57.123	2.966	0.026	90.889
11.533	0.000	0.000	0.000	0.000	13.589	55.801	2.979	0.033	91.089
11.533	23.835	1.410	0.664	104.292	13.599	54.735	2.992	0.039	91.265
11.630	23.630	1.428	2.532	104.953	13.609	53.844	3.005	0.045	91.429
11.732	23.672	1.446	3.854	107.359	13.618	53.078	3.017	0.052	91.579
11.845	23.742	1.465	2.595	106.189	13.628	52.406	3.030	0.058	91.723
11.946	23.829	1.483	2.218	105.265	13.628	0.000	0.000	0.000	0.000
12.049	23.925	1.502	2.033	103.269	13.628	52.406	3.030	0.000	91.487
12.152	24.028	1.521	1.920	103.075	13.629	172.087	3.044	0.000	44.073
12.259	24.134	1.540	1.843	102.924	13.629	136.974	3.058	0.000	49.180
12.359	24.245	1.559	1.787	102.798	13.630	121.393	3.072	0.000	51.876
12.462	24.357	1.578	1.743	102.688	13.631	112.087	3.086	0.001	53.867
12.565	24.472	1.598	1.705	102.584	13.632	105.723	3.100	0.001	55.441
12.565	0.000	0.000	0.000	0.000	13.632	101.013	3.115	0.001	56.740
12.565	46.519	2.580	0.001	91.876	13.633	97.344	3.129	0.001	57.843
12.584	75.875	2.582	0.011	89.108	13.634	94.378	3.143	0.002	58.799
12.605	66.343	2.585	0.014	89.780	13.634	91.914	3.157	0.002	59.643
12.621	61.917	2.588	0.025	90.388	13.635	89.823	3.171	0.002	88.343
12.640	59.156	2.591	0.037	90.644	13.635	0.000	0.000	0.000	0.000
12.659	57.189	2.594	0.048	90.879					
12.678	55.675	2.597	0.060	91.109					
12.697	54.452	2.600	0.071	91.314					
12.716	53.428	2.603	0.082	91.509					
12.735	52.550	2.606	0.093	91.691					
12.754	51.781	2.609	0.106	91.608					
12.754	0.000	0.000	0.000	0.000					
12.754	51.781	2.609	2.124	96.266					
12.796	51.624	2.622	0.429	92.797					
12.839	51.992	2.635	0.278	92.377					
12.882	50.426	2.649	0.311	92.570					
12.924	49.934	2.662	0.353	92.785					
12.967	49.506	2.675	0.399	93.003					
13.010	49.131	2.689	0.449	93.221					
13.052	48.800	2.702	0.503	93.439					
13.095	48.507	2.716	0.560	93.656					
13.138	48.245	2.729	0.621	93.875					
13.181	48.011	2.743	0.693	94.098					
13.181	0.000	0.000	0.000	0.000					

TABLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION OR LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 13,1964 1633CST

Y	C	U	V	T	Y	C	U	V	T
0.000	343.526	0.444	343.971	293.650	3122.542	332.567	21.441	354.009	275.213
185.000	342.648	1.809	344.457	292.150	3171.000	332.408	21.525	353.933	274.950
282.000	342.157	2.774	344.932	291.314	3248.000	331.984	21.538	353.523	274.249
379.000	341.649	3.747	345.396	290.450	3325.000	331.500	21.503	353.004	273.450
459.000	341.209	4.342	345.551	289.701	3403.000	331.022	21.542	352.564	272.661
539.000	340.766	4.944	345.710	288.950	3481.000	330.529	21.566	352.095	271.850
629.500	340.296	5.874	346.170	288.153	3554.500	330.015	21.565	351.580	271.005
720.000	339.821	6.826	346.647	287.350	3628.000	329.555	21.421	350.976	270.250
805.000	339.331	7.539	346.870	286.521	3696.500	329.250	21.003	350.253	269.750
886.000	338.874	8.245	347.119	285.750	3765.000	329.128	20.379	349.507	269.550
975.000	338.518	9.093	347.611	285.149	3847.000	329.433	19.411	348.844	270.050
1064.000	338.221	10.035	348.256	284.650	3929.000	329.677	18.355	348.032	270.450
1154.500	337.964	11.181	349.145	284.218	3987.000	329.317	17.553	346.869	269.859
1245.000	337.686	12.347	350.033	283.750	4045.000	328.823	16.927	345.749	269.050
1327.500	337.280	13.290	350.569	283.068	4110.000	328.544	16.780	345.324	268.595
1410.000	336.912	14.138	351.050	282.450	4175.000	328.272	16.821	345.093	268.150
1504.000	336.782	15.040	351.822	282.233	4254.000	327.733	16.821	344.554	267.270
1598.000	336.673	15.727	352.400	282.050	4333.000	327.230	16.796	344.026	266.450
1632.270	336.560	15.884	352.444	281.861	4386.500	327.122	16.704	343.827	266.275
1688.500	336.376	15.950	352.325	281.552	4440.000	327.046	16.535	343.580	266.150
1779.000	336.010	15.988	352.004	280.950	4501.000	326.735	16.241	342.975	265.644
1845.500	335.765	16.015	351.779	280.531	4562.000	326.431	15.888	342.319	265.150
1912.000	335.477	16.026	351.503	280.050					
1979.500	335.036	16.093	351.130	279.315					
2047.000	334.698	16.125	350.823	278.750					
2121.000	334.782	15.973	350.755	278.891					
2195.000	334.938	15.875	350.812	279.150					
2270.000	334.864	16.061	350.925	279.027					
2345.000	334.698	16.404	351.102	278.750					
2416.000	334.470	16.814	351.284	278.371					
2487.000	334.217	17.364	351.581	277.950					
2546.000	334.038	18.073	352.111	277.653					
2609.000	333.856	18.804	352.660	277.350					
2676.000	333.591	19.419	353.009	276.910					
2743.000	333.374	19.891	353.266	276.550					
2823.000	333.345	20.207	353.552	276.502					
2903.000	333.314	20.465	353.778	276.450					
2966.500	333.096	20.782	353.878	276.089					
3030.000	332.831	21.092	353.923	275.650					
3100.500	332.640	21.353	353.993	275.333					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS.
JM = NUMBER OF REFLECTING LAYERS.
IFOCUS = NUMBER OF FOCI.
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
MARCH 13,1964 1633CST	45	194	27	11	62

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI).
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS.
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS.
TINF = INTENSITY AT EACH FOCUS IN DB.
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN.

AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 13,1964 1633CST

PHI	XFOCUS	TINF	DXDPHI2
5.500	30.017	83.470	MAX
6.613	19.926	99.376	MIN
7.457	28.461	86.319	MAX
10.149	21.269	100.520	MIN
11.499	25.042	98.057	MAX
12.154	24.219	94.644	MIN
12.956	50.968	88.311	MIN
13.071	51.207	89.935	MAX
13.174	51.167	92.076	MIN
13.636	71.200	69.328	MAX
13.674	68.990	72.711	MIN

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 13,1964 1633CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	0.000	-0.000	1.000	0.000	5.754	23.292	0.539	0.412	102.309
0.303	2.410	0.003	1.022	118.138	5.896	22.258	0.561	0.609	103.039
0.609	4.593	0.012	1.142	113.015	6.039	21.534	0.580	0.779	105.125
0.914	6.432	0.026	1.290	110.621	6.181	20.959	0.598	0.911	101.080
1.219	7.917	0.044	1.484	109.425	6.324	20.478	0.614	1.025	102.335
1.523	9.098	0.064	1.714	108.842	6.466	20.063	0.629	1.596	105.225
1.827	10.039	0.086	1.970	108.592	6.466	0.000	0.000	0.000	0.000
2.132	10.796	0.110	2.246	108.529	6.466	20.063	0.629	1.596	105.225
2.436	11.412	0.134	2.535	108.572	6.599	19.927	0.644	16.205	111.800
2.741	11.921	0.159	2.833	108.677	6.731	20.014	0.660	2.201	109.262
3.045	12.347	0.185	4.164	113.129	6.864	20.284	0.678	1.045	103.293
3.045	0.000	0.000	0.000	0.000	6.996	20.760	0.697	0.635	101.467
3.045	12.340	0.185	4.142	113.038	7.129	21.516	0.720	0.391	105.261
3.292	12.502	0.206	8.396	112.982	7.129	0.000	0.000	0.000	0.000
3.539	12.564	0.225	20.156	116.742	7.129	21.516	0.720	0.391	105.261
3.785	12.589	0.245	50.448	120.709	7.187	22.010	0.731	0.302	103.481
4.031	12.596	0.263	283.218	128.272	7.245	22.682	0.744	0.222	102.485
4.286	12.594	0.282	4.989	127.242	7.302	23.630	0.759	0.153	101.955
4.287	0.000	0.000	0.000	0.000	7.360	25.122	0.777	0.084	99.931
4.286	12.594	0.282	4.989	127.242	7.418	28.314	0.803	0.130	97.258
4.460	12.787	0.297	1.819	106.144	7.418	0.000	0.000	0.000	0.000
4.652	13.178	0.313	1.086	103.640	7.418	28.314	0.803	0.130	97.258
4.836	13.756	0.332	0.756	101.697	7.480	28.412	0.829	0.872	97.008
5.021	14.574	0.353	0.533	99.677	7.542	27.779	0.847	0.377	95.532
5.213	15.775	0.379	0.330	96.904	7.604	27.209	0.862	0.411	95.981
5.213	0.000	0.000	0.000	0.000	7.666	26.709	0.875	0.454	96.478
5.213	15.775	0.379	0.330	96.904	7.727	26.266	0.886	0.533	97.120
5.265	16.321	0.388	0.261	95.585	7.727	0.000	0.000	0.000	0.000
5.320	17.077	0.398	0.189	93.796	7.727	26.266	0.886	0.533	97.120
5.375	18.161	0.411	0.122	91.369	7.843	25.715	0.906	0.793	98.544
5.430	20.101	0.427	0.036	104.943	7.958	25.317	0.924	0.998	99.547
5.484	29.548	0.459	0.087	86.634	8.074	24.984	0.942	1.130	107.058
5.484	0.000	0.000	0.000	0.000	8.189	24.689	0.959	1.230	103.859
5.484	29.548	0.459	0.087	86.634	8.305	24.422	0.975	1.305	104.114
5.538	27.003	0.491	0.131	96.168	8.305	0.000	0.000	0.000	0.000
5.592	25.545	0.507	0.204	98.985	8.305	24.422	0.975	1.305	104.114
5.646	24.591	0.519	0.280	103.838	8.444	24.122	0.994	1.379	101.450
5.700	23.873	0.530	0.347	101.706	8.584	23.847	1.012	1.448	101.733
5.754	23.292	0.539	0.412	102.309	8.724	23.590	1.030	1.510	101.997
5.754	0.000	0.000	0.000	0.000	8.864	23.350	1.047	1.569	102.306

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR (H=400.). THE RAY ZENITH FALLS OUTSIDE TOPPING-OUT LAYER (H=600.). OTHER POSSIBLE FAILURES COMPARE ZENITH AND MAX-MIN VALUES OF V RESPECTIVELY, AS FOLLOWS. AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN FOR A MIN OR LESS-THAN FOR A MAX (H=500.).

TABLES IV-BRAVO CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
9.000	23.124	1.064	1.451	102.343	12.722	54.565	2.603	0.116	84.252
9.000	0.000	0.000	0.000	0.000	12.754	53.601	2.609	0.149	85.927
9.000	23.124	1.064	1.451	102.343	12.754	0.000	0.000	0.000	0.000
9.179	22.785	1.084	1.244	102.381	12.754	53.601	2.609	0.149	85.927
9.358	22.429	1.103	1.190	102.775	12.803	52.465	2.620	0.208	87.982
9.537	22.082	1.121	1.192	103.341	12.853	51.676	2.632	0.305	91.329
9.707	21.751	1.138	1.211	104.120	12.902	51.178	2.645	0.548	106.082
9.886	21.437	1.155	1.619	105.838	12.952	50.969	2.659	6.329	99.548
9.886	0.000	0.000	0.000	0.000	13.002	51.117	2.676	1.497	97.220
9.886	21.437	1.155	1.619	105.838	13.002	0.000	0.000	0.000	0.000
10.044	21.292	1.170	4.150	110.395	13.002	51.117	2.676	1.497	97.220
10.204	21.275	1.186	9.224	109.365	13.038	51.199	2.689	3.072	107.728
10.364	21.363	1.204	2.279	107.206	13.073	51.207	2.703	108.078	111.951
10.525	21.562	1.223	1.222	104.893	13.109	51.197	2.716	10.800	104.361
10.685	21.895	1.245	0.778	103.708	13.145	51.182	2.729	9.460	105.417
10.685	0.000	0.000	0.000	0.000	13.181	51.168	2.743	18.347	104.854
10.685	21.895	1.245	0.778	103.708	13.181	0.000	0.000	0.000	0.000
10.777	22.100	1.258	0.614	103.193	13.181	51.168	2.743	18.347	104.854
10.866	22.499	1.273	0.482	102.683	13.220	51.202	2.758	2.563	111.566
10.959	22.934	1.289	0.373	102.351	13.260	51.285	2.774	1.461	94.397
11.050	23.508	1.307	0.280	102.083	13.299	51.407	2.790	1.061	93.213
11.141	24.300	1.328	0.315	106.242	13.338	51.567	2.806	0.835	92.201
11.141	0.000	0.000	0.000	0.000	13.378	51.766	2.823	0.543	90.628
11.141	24.300	1.328	0.315	106.242	13.378	0.000	0.000	0.000	0.000
11.220	24.712	1.346	0.568	103.864	13.378	51.766	2.823	0.543	90.628
11.298	24.901	1.363	1.207	104.670	13.408	52.027	2.837	0.365	89.329
11.376	24.994	1.380	2.555	107.388	13.439	52.406	2.851	0.267	88.125
11.455	25.034	1.395	7.887	109.907	13.470	52.907	2.867	0.205	87.118
11.533	25.037	1.410	7.152	107.197	13.501	53.561	2.884	0.158	85.998
11.533	0.000	0.000	0.000	0.000	13.531	54.422	2.903	0.105	84.498
11.533	25.037	1.410	7.152	107.197	13.531	0.000	0.000	0.000	0.000
11.652	24.937	1.431	1.969	105.160	13.531	54.422	2.903	0.105	84.498
11.774	24.779	1.451	1.483	104.073	13.545	54.980	2.912	0.080	83.569
11.894	24.600	1.470	1.338	103.836	13.558	55.751	2.922	0.058	82.388
12.014	24.413	1.487	1.277	104.140	13.571	56.833	2.934	0.040	80.988
12.135	24.223	1.504	5.032	106.566	13.585	58.489	2.948	0.023	78.529
12.135	0.000	0.000	0.000	0.000	13.598	61.706	2.966	0.016	72.039
12.135	24.223	1.504	5.032	106.566	13.598	0.000	0.000	0.000	0.000
12.221	24.263	1.516	1.194	106.787	13.598	61.706	2.966	0.016	72.039
12.307	24.505	1.530	0.462	103.862	13.604	63.466	2.978	0.016	71.821
12.393	24.993	1.546	0.238	107.338	13.610	65.106	2.989	0.017	71.762
12.479	25.941	1.567	0.098	97.940	13.616	66.821	3.002	0.016	71.343
12.565	28.578	1.598	0.032	89.941	13.622	68.708	3.015	0.015	70.713
12.565	0.000	0.000	0.000	0.000	13.628	70.877	3.030	0.022	83.349
12.565	28.578	1.598	0.032	89.941	13.628	0.000	0.000	0.000	0.000
12.571	29.052	1.602	0.027	89.585	13.628	70.869	3.030	0.022	83.098
12.578	29.672	1.606	0.020	79.242	13.637	71.194	3.050	0.445	85.137
12.584	30.553	1.611	0.013	77.079	13.647	70.653	3.066	0.085	79.194
12.591	32.076	1.617	0.000	50.799	13.656	70.068	3.079	0.083	79.298
12.597	1000.000	1.632	0.000	0.000	13.666	69.515	3.090	0.088	79.823
12.597	0.000	0.000	0.000	0.000	13.675	69.006	3.101	0.219	82.619
12.597	1000.000	2.581	0.000	0.000	13.675	0.000	0.000	0.000	0.000
12.628	60.999	2.586	0.000	72.529	13.675	69.006	3.101	0.219	82.619
12.660	57.774	2.591	0.055	79.757	13.677	69.088	3.103	0.051	83.128
12.691	55.680	2.597	0.084	82.210	13.679	69.411	3.105	0.021	80.716

TABLES IV-CRAVO CONTINUED: PART 3

PHI	X	H	F	TINS	PHI	X	H	F	TINS
13.681	76.063	3.109	0.010	79.301					
13.683	71.441	3.113	0.000	74.246					
13.685	1000.000	3.123	0.000	0.000					
13.685	0.000	0.000	0.000	0.000					

TABLES I-ABLE

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

Y = LEVELS IN METERS,
= SUBDIVISION ON LOCAL-MAX IF DECIMALS SPECIFIED,
= MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 20,1964 1618CST

Y	C	U	V	T	Y	C	U	V	T
0.000	343.819	1.521	345.340	294.150					
148.000	342.765	1.273	344.038	292.350					
272.000	341.943	3.712	345.655	290.950					
433.000	341.179	5.322	346.500	289.650					
569.000	340.235	6.013	346.248	288.050					
689.000	339.762	6.386	346.148	287.250					
837.000	338.755	7.023	345.778	285.550					
959.000	338.102	7.817	345.919	284.450					
1101.000	337.090	8.693	345.783	282.750					
1265.000	336.315	9.437	345.752	281.450					
1422.000	335.836	10.576	346.412	280.650					
1591.000	335.477	12.095	347.572	280.050					
1743.000	334.577	13.102	347.679	278.550					
1907.000	334.036	13.842	347.878	277.650					
2043.000	333.675	14.973	348.648	277.050					
2190.000	332.771	16.361	349.132	275.550					
2340.000	332.045	17.121	349.167	274.350					
2460.000	331.318	17.448	348.767	273.150					
2581.000	330.833	17.738	348.571	272.350					
2703.000	330.225	18.225	348.450	271.350					
2826.000	329.494	18.806	348.300	270.150					
2963.000	328.639	18.948	347.587	268.750					
3076.000	327.966	18.307	346.273	267.650					
3194.000	327.230	18.134	345.364	266.450					
3324.000	326.738	18.952	345.690	265.650					
3455.000	326.615	20.527	347.142	265.450					
3576.000	326.123	22.130	348.252	264.650					
3699.000	325.259	23.549	348.808	263.250					
3811.000	324.702	24.811	349.514	262.350					
3911.000	324.207	26.345	350.552	261.550					
4051.000	324.021	28.127	352.148	261.250					
4180.000	323.649	28.802	352.451	260.650					
4311.000	322.903	29.457	352.359	259.450					
4431.000	323.089	31.708	354.797	259.750					
4553.000	323.338	33.858	357.196	260.150					
4663.000	323.027	34.977	358.004	259.650					
4774.000	322.654	36.450	359.103	259.050					

TABLES II-ABLE

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
MARCH 20,1964 1618CST	45	192	16	7	37

TABLES III-ABLE

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY STRAIGHT-STEPPED LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,
AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 20,1964 1618CST

PHI	XFOCUS	TINF	DXDPHI2
4.885	57.203	88.079	MAX
6.530	77.432	67.484	MAX
6.699	77.876	71.391	MAX
7.984	58.621	77.878	MAX
8.475	111.857	55.465	MAX
11.340	72.361	70.713	MAX
11.741	60.959	85.833	MAX

TABLES IV-ABLE

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY STRAIGHT-STEPPED LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES.
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS.
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX.
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS.
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY.
F = DIMENSIONLESS VALUE OF FOCUS FACTOR.
TINS = SOUND INTENSITY IN DB.
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES.
AZIMUTH = 45 DEGREES. DATE-TIME = MARCH 20.1964 1618CST

PHI		X	H	F	TINS	PHI	X	H	F	TINS
0.000		11.310	0.248	67.232	122.994	6.572	54.924	1.651	0.045	101.916
0.245		10.991	0.248	35.952	120.577	6.588	52.591	1.667	0.060	99.727
0.490		10.699	0.249	19.192	118.142	6.603	50.822	1.682	0.074	94.575
0.735		10.434	0.250	13.793	116.968	6.618	49.411	1.697	0.089	93.622
0.981		10.195	0.252	11.271	116.321	6.634	48.243	1.712	0.103	96.569
1.226		9.981	0.254	9.941	115.969	6.649	47.250	1.728	0.118	95.653
1.471		9.793	0.257	9.254	115.819	6.665	46.388	1.743	0.134	96.098
1.716		9.629	0.260	8.998	115.829	6.665	0.000	0.000	0.000	0.000
1.961		9.487	0.263	9.093	115.980	6.665	46.388	1.743	0.004	95.852
2.206		9.368	0.267	9.543	116.272	6.692	76.656	1.759	0.032	82.675
2.451		9.269	0.272	10.499	116.551	6.720	66.303	1.775	0.035	87.655
2.451	T	0.000	0.000	0.000	0.000	6.747	61.265	1.791	0.060	88.854
2.451		9.269	0.272	0.482	103.166	6.775	58.000	1.808	0.083	93.952
2.676		10.641	0.284	0.914	117.912	6.803	55.601	1.824	0.105	102.334
2.901		11.226	0.296	1.635	122.499	6.830	53.710	1.841	0.125	100.918
3.126		11.704	0.310	1.843	106.969	6.858	52.151	1.857	0.145	99.114
3.351		12.139	0.324	1.924	106.839	6.885	50.825	1.874	0.163	94.580
3.576		12.550	0.340	1.941	106.589	6.913	49.671	1.890	0.181	93.477
3.801		12.951	0.356	1.925	106.280	6.940	48.649	1.907	0.201	94.041
4.026		13.345	0.374	1.891	105.942	6.940	0.000	0.000	0.000	0.000
4.251		13.738	0.393	1.849	105.591	6.940	48.649	1.907	3.262	98.645
4.476		14.130	0.412	1.803	105.237	7.038	48.107	1.920	0.757	95.545
4.706		14.524	0.433	1.758	104.890	7.136	46.896	1.933	0.574	95.710
4.706		0.000	0.000	0.000	0.000	7.233	45.882	1.946	0.661	96.102
4.706		50.304	1.435	0.145	93.504	7.331	45.032	1.959	0.758	96.599
4.881		57.201	1.448	8.264	100.616	7.428	44.308	1.973	0.859	97.057
5.062		50.896	1.462	0.365	94.730	7.526	43.683	1.986	0.961	99.664
5.243		47.263	1.476	0.524	95.651	7.624	43.136	2.000	1.066	100.593
5.424		44.692	1.491	0.654	96.813	7.721	42.653	2.014	1.174	98.575
5.605		42.715	1.507	0.771	98.595	7.819	42.224	2.029	1.285	98.710
5.786		41.126	1.522	0.884	94.200	7.917	41.838	2.043	1.413	98.950
5.967		39.813	1.539	0.995	93.669	7.917	0.000	0.000	0.000	0.000
6.146		38.708	1.556	1.108	94.379	7.917	41.838	2.043	0.011	96.893
6.329		37.765	1.573	1.225	95.027	7.972	58.082	2.057	0.081	93.846
6.516		36.952	1.591	1.369	95.692	8.027	51.711	2.072	0.074	97.436
6.516	+	0.000	0.000	0.000	0.000	8.083	48.531	2.086	0.125	98.143
6.516		36.952	1.591	0.001	65.668	8.138	46.418	2.101	0.169	96.089
6.526		75.666	1.606	0.013	93.636	8.193	44.825	2.115	0.209	96.729
6.541		83.697	1.621	0.017	88.333	8.249	43.536	2.130	0.244	99.573
6.557		56.255	1.636	0.031	93.794	8.304	42.448	2.145	0.276	98.580

TABLES IV-ABLE CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
8.360	41.499	2.160	0.305	93.983	11.383	62.039	4.089	0.053	88.980
8.415	40.650	2.175	0.331	94.492	11.407	60.137	4.102	0.078	94.768
8.470	39.893	2.190	0.359	94.964	11.432	58.767	4.115	0.102	94.100
8.470	0.000	0.000	0.000	0.000	11.456	57.699	4.128	0.125	93.761
8.470	39.893	2.190	0.000	93.623	11.480	56.824	4.141	0.148	103.001
8.474	108.551	2.205	0.002	58.037	11.505	56.080	4.154	0.169	102.615
8.476	88.370	2.220	0.003	78.309	11.529	55.433	4.167	0.189	102.213
8.482	79.401	2.235	0.005	82.519	11.554	54.856	4.180	0.212	101.874
8.485	74.034	2.250	0.007	84.365	11.554	0.000	0.000	0.000	0.000
8.490	70.355	2.265	0.010	86.169	11.554	55.550	4.316	0.082	102.303
8.494	67.627	2.280	0.013	87.875	11.727	60.932	4.326	1.234	93.018
8.497	65.495	2.295	0.015	87.669	11.901	56.989	4.337	0.261	103.081
8.501	63.768	2.310	0.018	88.306	12.074	54.654	4.348	0.380	101.664
8.505	62.329	2.325	0.021	88.862	12.247	52.924	4.360	0.470	100.129
8.509	61.104	2.340	0.025	88.937	12.421	51.518	4.371	0.543	96.941
8.509	0.000	0.000	0.000	0.000	12.594	50.316	4.383	0.603	93.114
8.509	104.683	3.756	0.038	71.533	12.767	49.258	4.395	0.655	93.708
8.546	95.235	3.761	0.060	74.160	12.941	48.308	4.407	0.701	96.982
8.584	90.850	3.767	0.107	76.971	13.114	47.443	4.419	0.742	95.626
8.621	87.892	3.772	0.145	78.543	13.287	46.648	4.431	0.786	95.864
8.659	85.636	3.778	0.179	79.676	13.287	0.000	0.000	0.000	0.000
8.696	83.799	3.783	0.210	80.554	13.287	46.648	4.431	0.842	95.971
8.735	82.240	3.789	0.239	81.270	13.442	46.023	4.443	0.846	96.027
8.771	80.862	3.794	0.266	81.875	13.597	45.418	4.454	0.861	96.368
8.808	79.675	3.800	0.292	82.400	13.752	44.845	4.466	0.886	96.717
8.845	78.586	3.805	0.316	82.866	13.907	44.301	4.478	0.912	97.062
8.883	77.593	3.811	0.343	83.321	14.061	43.785	4.490	0.938	99.766
8.883	0.000	0.000	0.000	0.000	14.216	43.294	4.502	0.962	100.137
8.883	77.593	3.811	0.237	81.766	14.371	42.825	4.515	0.986	101.217
8.982	74.300	3.820	0.300	84.244	14.526	42.378	4.527	1.010	98.621
9.089	71.948	3.830	0.374	85.268	14.681	41.950	4.540	1.033	98.889
9.192	69.966	3.840	0.420	86.289	14.835	41.540	4.553	1.058	96.772
9.295	68.242	3.850	0.576	87.569	14.835	0.000	0.000	0.000	0.000
9.392	67.358	3.860	0.631	88.006	14.835	41.540	4.553	0.101	94.322
9.502	65.919	3.870	0.517	87.525	14.884	42.523	4.564	0.204	98.537
9.605	64.618	3.880	0.552	87.984	14.932	42.859	4.575	0.476	101.170
9.702	63.430	3.890	0.586	88.436	14.980	43.091	4.586	0.660	100.709
9.811	62.338	3.900	0.618	88.858	15.028	43.270	4.597	0.837	100.207
9.914	61.329	3.911	0.653	89.282	15.077	43.416	4.608	1.015	99.640
9.914	0.000	0.000	0.000	0.000	15.125	43.538	4.619	1.196	99.573
9.914	61.329	3.911	0.566	88.821	15.173	43.642	4.630	1.383	99.630
10.054	59.919	3.924	0.628	94.671	15.221	43.734	4.641	1.574	99.707
10.193	58.710	3.937	0.689	94.068	15.270	43.814	4.652	1.772	99.799
10.333	57.610	3.951	0.728	93.702	15.318	43.886	4.663	1.999	99.664
10.472	56.598	3.965	0.728	102.888	15.318	0.000	0.000	0.000	0.000
10.612	55.562	3.979	0.756	102.310	15.318	43.886	4.663	0.295	99.921
10.751	54.688	3.993	0.830	101.688	15.381	43.439	4.674	0.584	99.545
10.891	53.872	4.007	0.864	101.060	15.444	43.291	4.685	1.369	100.146
11.030	53.109	4.021	0.897	100.332	15.507	43.187	4.696	1.805	100.457
11.170	52.393	4.036	0.930	99.464	15.570	43.102	4.707	2.139	100.685
11.309	51.720	4.051	0.965	98.389	15.633	43.028	4.718	2.400	100.865
11.309	0.000	0.000	0.000	0.000	15.696	42.961	4.729	2.608	101.003
11.309	51.720	4.051	0.003	97.458	15.759	42.899	4.740	2.775	101.111
11.334	71.514	4.064	0.023	85.615	15.822	42.840	4.751	2.912	101.198
11.356	65.058	4.077	0.029	87.817	15.885	42.784	4.763	3.027	101.269

TABLES IV-TABLE CONTINUED, PART 3

PHI	X	H	F	TINS	PHI	X	H	F	TINS
15.945	42.731	4.774	3.138	101.336					
15.945	0.000	0.000	0.000	0.000					

TAPLES I-BRAVO

SOUND PROPAGATION SOUNDING OF
THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

Y = LEVELS IN METERS,
  = SUBDIVISION OF LOCAL-MAX IF DECIMALS SPECIFIED,
  = MID-POINT BETWEEN PARABOLIC JOIN-POINTS FOR .5-METER,
C = SPEED OF SOUND IN METERS PER SECOND,
U = WIND COMPONENT NORMAL TO THE SURFACES OF
    EXPANDING SOUND WAVES IN METERS PER SECOND,
V = C + U IN METERS PER SECOND,
T = TEMPERATURE IN DEGREES ABSOLUTE,

AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 20,1964 1618CST

Y	C	U	V	T	Y	C	U	V	T
0.000	343.819	1.521	345.340	294.150	2642.000	330.544	17.963	348.507	271.874
148.000	342.765	1.273	344.038	292.350	2703.000	330.225	18.225	348.450	271.350
210.000	342.334	2.397	344.730	291.615	2764.500	329.869	18.540	348.409	270.766
272.000	341.943	3.712	345.655	290.950	2826.000	329.494	18.806	348.300	270.150
352.500	341.565	4.647	346.211	290.306	2894.500	329.066	18.959	348.025	269.449
433.000	341.179	5.322	346.500	289.650	2963.000	328.639	18.948	347.587	268.750
455.502	341.021	5.502	346.523	289.382	3020.500	328.303	18.650	346.953	268.201
501.000	340.703	5.729	346.432	288.843	3078.000	327.966	18.307	346.273	267.650
569.000	340.235	6.013	346.248	288.050	3136.000	327.582	18.131	345.713	267.023
629.000	339.998	6.206	346.204	287.650	3194.000	327.230	18.134	345.364	266.450
689.000	339.762	6.386	346.148	287.250	3259.000	326.941	18.436	345.378	265.980
763.000	339.270	6.676	345.946	286.419	3324.000	326.738	18.952	345.690	265.650
837.000	338.755	7.023	345.778	285.550	3389.500	326.678	19.683	346.361	265.552
895.000	338.431	7.404	345.836	285.004	3455.000	326.615	20.527	347.142	265.450
959.000	338.102	7.817	345.919	284.450	3515.500	326.416	21.332	347.748	265.126
959.709	338.097	7.823	345.919	284.440	3576.000	326.123	22.130	348.252	264.650
1030.000	337.588	8.273	345.861	283.586	3637.500	325.698	22.854	348.553	263.962
1101.000	337.090	8.693	345.783	282.750	3699.000	325.259	23.549	348.808	263.250
1163.000	336.663	9.053	345.716	282.033	3755.000	324.966	24.155	349.121	262.775
1225.000	336.315	9.437	345.752	281.450	3811.000	324.702	24.811	349.514	262.350
1343.500	336.049	9.962	346.011	281.006	3861.000	324.428	25.570	349.999	261.907
1422.000	335.836	10.576	346.412	280.650	3911.000	324.207	26.345	350.552	261.550
1506.500	335.685	11.341	347.026	280.398	3981.000	324.101	27.318	351.419	261.378
1591.000	335.477	12.095	347.572	280.050	4051.000	324.021	28.127	352.148	261.250
1651.122	335.131	12.560	347.690	279.472	4115.500	323.871	28.530	352.400	261.008
1667.000	335.039	12.643	347.682	279.320	4180.000	323.649	28.802	352.451	260.650
1743.000	334.577	13.102	347.679	278.550	4187.295	323.603	28.851	352.454	260.577
1825.000	334.275	13.457	347.732	278.047	4245.500	323.242	29.024	352.265	259.995
1907.000	334.036	13.842	347.878	277.650	4311.000	322.903	29.457	352.359	259.450
1975.000	333.881	14.362	348.243	277.391	4371.000	322.936	30.483	353.419	259.503
2043.000	333.675	14.973	348.648	277.050	4431.000	323.089	31.708	354.797	259.750
2116.500	333.242	15.698	348.939	276.330	4492.000	323.245	32.846	356.091	260.001
2193.000	332.771	16.361	349.132	275.550	4553.000	323.338	33.858	357.196	260.150
2265.000	332.406	16.801	349.207	274.946					
2277.476	332.346	16.863	349.209	274.847					
2340.000	332.045	17.121	349.167	274.350					
2400.000	331.677	17.307	348.984	273.741					
2460.000	331.318	17.448	348.767	273.150					
2520.500	331.068	17.583	348.651	272.737					
2581.000	330.833	17.738	348.571	272.350					

TABLES II-BRAVO

SOME SOUND PROPAGATION CHARACTERISTICS OF THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

IMAX = TOTAL NUMBER OF RAYS,
JM = NUMBER OF REFLECTING LAYERS,
IFOCUS = NUMBER OF FOCI,
LMAX = NUMBER OF LAYERS.

DATE-TIME	AZIMUTH (DEG.)	IMAX	JM	IFOCUS	LMAX
MARCH 20,1964 1618CST	45	196	27	7	73

TABLES III-BRAVO

DISTANCE TO FOCAL POINTS AND VALUE OF SOUND INTENSITY THERE
IN THE ATMOSPHERE REPRESENTED BY PARABOLIC-SMOOTH LAYERS

(NO TABULAR ENTRIES IF THERE ARE NO FOCI),
PHI = INITIAL INCLINATION OF RAY REACHING FOCUS,
XFOCUS = DISTANCE TO EACH FOCUS IN KILOMETERS,
TINF = INTENSITY AT EACH FOCUS IN DB,
DXDPHI2 = FOCAL-TYPE, VIZ.
= MIN, IF RAYS RANGE FIRST INWARD TOWARD SOUND-SOURCE BUT THEN BACK OUTWARD, OR
= MAX, IF (WITH INCREASING INITIAL-INCLINATION) RAYS RANGE OUTWARD FROM SOURCE TO FOCUS BUT THEN BACK IN,

AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 20,1964 1618CST

PHI	XFOCUS	TINF	DXDPHI2
1.518	8.389	115.293	MIN
6.295	36.054	95.339	MIN
6.700	54.949	58.474	MIN
6.752	66.016	74.325	MAX
7.785	39.722	93.420	MIN
11.200	52.805	90.650	MIN
14.756	42.124	95.186	MIN

TABLES IV-BRAVO

SOUND INTENSITY AT LANDING DISTANCES OF SOUND RAYS REPRESENTED BY PARABOLIC-SMOOTH LAYERS

PHI = INITIAL ELEVATION ANGLE OF SOUND-RAY IN DEGREES,
X = LANDING DISTANCE OF SOUND-RAYS IN KILOMETERS,
= 1000. INDICATES INFINITE TRAVEL OF RAY WITH ZENITH AT SOUNDING MAX,
H = TOPPING OUT HEIGHT OF SOUND-RAYS IN KILOMETERS,
= HT. CORRESPONDING TO VTEST FOR INFINITELY RANGING BOTTOM-RAY,
F = DIMENSIONLESS VALUE OF FOCUS FACTOR,
TINS = SOUND INTENSITY IN DB,
ROW OF ZEROS FLAG REFRACTING-LAYER BOUNDARIES,
AZIMUTH = 45 DEGREES, DATE-TIME = MARCH 20,1964 1618CST

PHI	X	H	F	TINS	PHI	X	H	F	TINS
0.000	8.950	0.244	119.063	127.519	5.663	39.034	1.506	0.785	93.200
0.245	8.801	0.245	63.348	125.054	5.663	0.000	0.000	0.000	0.000
0.490	8.672	0.245	36.347	123.030	5.663	39.034	1.506	0.785	93.200
0.735	8.563	0.246	29.281	122.574	5.832	37.753	1.518	0.995	95.119
0.981	8.477	0.248	29.198	123.061	6.002	36.836	1.532	1.381	97.240
1.226	8.418	0.250	38.881	125.335	6.171	36.252	1.548	2.628	102.412
1.471	8.390	0.253	184.195	129.858	6.341	36.081	1.566	4.803	101.351
1.716	8.402	0.256	31.542	128.984	6.510	36.652	1.591	0.673	98.283
1.961	8.466	0.260	10.542	123.303	6.510	0.000	0.000	0.000	0.000
2.206	8.603	0.266	4.916	122.648	6.510	36.652	1.591	0.673	98.283
2.451	8.855	0.272	3.380	126.127	6.544	36.969	1.597	0.481	96.892
2.451	0.000	0.000	0.000	0.000	6.578	37.447	1.604	0.312	95.783
2.451	8.855	0.272	3.380	126.127	6.612	38.205	1.613	0.178	94.448
2.683	9.112	0.279	3.001	111.261	6.646	39.643	1.624	0.000	92.444
2.915	9.379	0.288	2.587	110.365	6.680	1000.000	1.651	0.000	0.000
3.147	9.688	0.297	2.105	109.188	6.680	0.000	0.000	0.000	0.000
3.379	10.057	0.308	1.675	107.870	6.680	1000.000	1.755	0.000	0.000
3.611	10.511	0.321	1.305	106.403	6.692	55.330	1.765	0.000	92.273
3.843	11.090	0.335	0.986	104.719	6.704	55.019	1.776	0.207	92.583
4.075	11.867	0.353	0.733	102.844	6.716	56.262	1.789	0.052	91.370
4.075	0.000	0.000	0.000	0.000	6.728	58.808	1.804	0.026	89.893
4.075	11.867	0.352	0.733	102.844	6.739	64.072	1.825	0.031	87.417
4.206	12.406	0.363	0.611	101.670	6.739	0.000	0.000	0.000	0.000
4.325	13.075	0.376	0.487	100.225	6.739	64.072	1.825	0.031	87.417
4.450	13.957	0.391	0.361	98.359	6.780	57.011	1.857	0.066	90.971
4.575	15.246	0.408	0.227	95.574	6.820	53.935	1.874	0.125	93.423
4.700	17.628	0.433	0.099	90.692	6.860	51.967	1.886	0.177	89.512
4.700	0.000	0.000	0.000	0.000	6.900	50.511	1.897	0.224	90.643
4.700	17.628	0.433	0.099	90.692	6.940	49.351	1.907	0.255	91.992
4.716	17.985	0.435	0.080	89.595	6.940	0.000	0.000	0.000	0.000
4.719	18.495	0.438	0.056	87.823	6.940	49.351	1.907	0.255	91.992
4.726	19.251	0.441	0.035	85.461	7.036	46.956	1.926	0.301	94.260
4.737	20.587	0.445	0.000	58.450	7.132	45.124	1.940	0.365	95.331
4.746	1000.000	0.456	0.000	0.000	7.228	43.657	1.953	0.426	96.100
4.746	0.000	0.000	0.000	0.000	7.323	42.427	1.965	0.481	98.096
4.746	1000.000	1.441	0.000	0.000	7.419	41.362	1.975	0.583	96.148
4.929	50.508	1.455	0.004	90.645	7.419	0.000	0.000	0.000	0.000
5.113	46.085	1.468	0.447	94.925	7.419	41.362	1.975	0.583	96.148
5.296	43.137	1.481	0.572	96.545	7.519	40.584	1.986	0.832	97.948
5.480	40.877	1.494	0.665	97.314	7.618	40.079	1.998	1.314	99.285

FOOTNOTE - A RAY FAILS TO REACH UP TO A LAYER SUPERJACENT (H=200.) OR SUBJACENT (H=300.) TO A MAX OR ONE WHICH IS LINEAR (H=400.). THE RAY ZENITH FALLS OUTSIDE TOPPING-OUT LAYER (H=600.). OTHER POSSIBLE FAILURES COMPARE ZENITH AND MAX-MIN VALUES OF V RESPECTIVELY, AS FOLLOWS. AS BEING LESS-THAN, FOR A MIN (H=100.). AS BEING GREATER THAN FOR A MIN OR LESS-THAN FOR A MAX (H=500.).

TABLES IV-BRAVO CONTINUED, PART 2

PHI	X	H	F	TINS	PHI	X	H	F	TINS
7.710	39.792	2.011	2.990	102.771	10.227	58.252	3.940	0.671	90.238
7.817	39.738	2.026	5.115	101.372	10.383	56.986	3.954	0.693	90.985
7.917	39.989	2.043	1.717	99.958	10.539	55.803	3.968	0.714	91.790
7.917	0.000	0.000	0.000	0.000	10.696	54.694	3.981	0.792	92.298
7.917	39.989	2.043	1.717	99.958	10.696	0.000	0.000	0.000	0.000
7.984	40.205	2.056	1.560	98.990	10.696	54.694	3.981	0.792	92.298
8.052	40.423	2.070	1.414	98.455	10.818	53.979	3.992	0.948	93.318
8.119	40.682	2.085	1.166	97.717	10.941	53.418	4.004	1.224	94.608
8.187	41.000	2.100	0.945	97.052	11.064	53.012	4.017	1.902	96.701
8.255	41.393	2.117	0.653	96.078	11.187	52.807	4.032	15.777	103.367
8.255	0.000	0.000	0.000	0.000	11.309	52.939	4.051	1.285	100.594
8.255	41.393	2.116	0.653	96.078	11.309	0.000	0.000	0.000	0.000
8.298	41.773	2.128	0.472	95.424	11.309	52.939	4.051	1.285	100.594
8.341	42.307	2.140	0.342	98.700	11.350	53.120	4.058	0.767	96.026
8.384	43.043	2.154	0.246	96.690	11.391	53.431	4.067	0.445	94.566
8.427	44.098	2.170	0.164	95.829	11.432	53.969	4.077	0.235	93.336
8.470	45.771	2.190	0.107	95.049	11.473	55.046	4.090	0.059	93.069
8.470	0.000	0.000	0.000	0.000	11.513	60.569	4.115	0.015	88.829
8.470	45.771	2.190	0.107	95.049	11.513	0.000	0.000	0.000	0.000
8.487	46.682	2.199	0.088	94.483	11.513	60.569	4.116	0.015	88.829
8.504	47.841	2.209	0.067	93.445	11.521	63.645	4.129	0.018	87.781
8.520	49.463	2.222	0.044	91.869	11.530	65.575	4.142	0.026	86.671
8.537	52.100	2.237	0.017	89.369	11.538	67.111	4.155	0.033	86.138
8.554	61.702	2.265	0.003	88.493	11.546	68.412	4.167	0.039	85.749
8.554	0.000	0.000	0.000	0.000	11.554	69.550	4.180	0.015	85.312
8.554	61.688	2.265	0.003	88.497	11.554	0.000	0.000	0.000	0.000
8.554	62.595	2.266	0.003	88.174	11.554	69.543	4.180	0.015	85.316
8.554	63.763	2.268	0.002	87.740	11.554	69.738	4.181	0.010	85.054
8.555	65.418	2.270	0.001	86.726	11.555	70.095	4.182	0.006	84.901
8.555	68.261	2.272	0.000	85.792	11.555	70.694	4.183	0.003	84.688
8.556	1000.000	2.277	0.000	0.000	11.556	71.842	4.184	0.000	84.292
8.556	0.000	0.000	0.000	0.000	11.556	1000.000	4.187	0.000	0.000
8.556	1000.000	3.769	0.000	0.000	11.556	0.000	0.000	0.000	0.000
8.621	93.785	3.778	0.002	65.011	11.556	1000.000	4.320	0.000	0.000
8.686	87.541	3.787	0.129	78.153	11.705	60.721	4.334	0.002	88.740
8.752	83.671	3.795	0.184	80.011	11.854	57.044	4.345	0.237	90.956
8.817	80.783	3.803	0.228	81.220	12.003	54.765	4.354	0.334	92.220
8.883	78.444	3.811	0.263	82.091	12.152	53.034	4.363	0.404	96.571
8.883	0.000	0.000	0.000	0.000	12.301	51.598	4.371	0.469	89.783
8.882	78.444	3.811	0.263	82.091	12.301	0.000	0.000	0.000	0.000
8.982	75.510	3.822	0.308	83.089	12.301	51.598	4.371	0.469	89.783
9.081	73.066	3.833	0.348	83.899	12.498	50.079	4.381	0.565	91.164
9.180	70.959	3.842	0.384	84.597	12.695	48.846	4.393	0.658	92.498
9.280	69.100	3.852	0.416	85.389	12.893	47.808	4.404	0.748	93.475
9.379	67.433	3.861	0.452	86.026	13.090	46.923	4.417	0.849	94.290
9.379	0.000	0.000	0.000	0.000	13.287	46.171	4.431	0.906	94.879
9.379	67.433	3.861	0.452	86.026	13.287	0.000	0.000	0.000	0.000
9.480	65.861	3.871	0.498	86.570	13.287	46.171	4.431	0.906	94.879
9.590	64.474	3.881	0.541	87.053	13.459	45.532	4.443	0.898	95.150
9.700	63.226	3.891	0.581	87.936	13.631	44.902	4.456	0.895	95.432
9.807	62.094	3.901	0.619	88.360	13.802	44.292	4.468	0.904	95.732
9.914	61.057	3.911	0.641	88.667	13.974	43.706	4.480	0.915	96.056
9.914	0.000	0.000	0.000	0.000	14.145	43.143	4.492	1.007	96.536
9.914	61.057	3.911	0.641	88.667	14.145	0.000	0.000	0.000	0.000
10.070	59.611	3.926	0.653	89.414	14.145	43.143	4.492	1.007	96.536

TABLES IV-BRAVO CONTINUED, PART 3

PHI	x	H	F	TINS	PHI	x	H	F	TINS
14.285	42.706	4.512	1.212	97.118					
14.421	42.475	4.513	1.561	97.831					
14.559	42.259	4.525	2.315	98.932					
14.697	42.136	4.538	6.863	102.415					
14.835	42.146	4.553	5.069	104.351					
14.835	0.000	0.000	0.000	0.000					

CHAPTER IV

A DISCUSSION OF SOME RESULTS

CHAPTER IV

The previous chapter tabulated the numerical results in the comparison of the ray tracing methods. A detailed examination of these tabulations ought to yield some insight into the comparison being sought. Through a recourse only to Tables I - V of Chapter III, however, it becomes somewhat awkward to report concisely or clearly upon a discussion of such an examination.

For a didactic purpose, therefore, this chapter supplements the previous one with a narrative approach to reporting the discussion. From the tables of Chapter III, a selection of numerical information has been converted into graphical form in this chapter. The selection has been made for offering convincing evidence in support of conclusions having been theoretically concluded (or suspicioned in earlier phases of this study).

Such a selective and descriptive approach is, of course, a limitation to any disinterested effort for attempting to arrive at impartial results.

In this chapter, therefore, the purpose is only to increase awareness and understanding of the differences between the two ray tracing methods, in as convincing a manner as possible.

After having presented certain ranging properties of rays as a function of their initial inclination angle, the chapter proceeds to present some evidence as to the positive discontinuities in the linear sounding and their relation to the ranging properties of rays. In the same way, negative discontinuities shall be presented, as well as those which attend the local maxima in the linear sounding. With the completion of a discussion of these

three sorts of discontinuities, the way is ready for examining the effects of linear representation upon the distribution of propagated sound intensity. A comparison can then be drawn between the two representations: linear vis-a-vis non-linear. The chapter ends with a discussion of focus criteria and proper foci.

A. THE RANGING PROPERTIES OF RAYS AS A FUNCTION OF THEIR INITIAL INCLINATION ANGLE

The linearized variation along the local vertical of the horizontal wind- and sound-speed introduces false foci in the outward ranging of sound intensity from the local source (or back inward to it). This falsification results from a violation of a basic assumption on which the ray tracing technique has been based. Ray tracing assumes that the sound intensity is not too great, that perturbations of the medium are small, or that changes in the atmospheric medium are small over the wave-length distance, or that the variations take place smoothly. This violation is especially risked when considering low-frequency sound (small wave-number).

In a previous report (1966, p. 97 ff.), an arithmetical exercise was carried out to reveal the general nature of this risk. There, the ranging properties of rays were considered theoretically, as a function of their initial inclination angle. From that consideration, it was concluded that, for all initial inclination angles such that the ray becomes tangent to a horizontal interface between layers with constant gradient of wind- and sound-speed, the basic assumption of smooth variation of the atmospheric parameters is violated for any wavelength and, consequently, the sound intensity calculated at these points cannot be considered as correct. Since then, a numerical exercise has been carried out to verify this conclusion and to assess the magnitude of the falsification involved. In this report the results of that numerical exercise are now presented.

Consider a horizontal interface between two, adjacent atmospheric layers within each of which the vertical variation of the wind- and sound-speed is constant. In terms of its initial inclination, a ray ranges discontinuously whenever its zenith coincides with an interface at which the wind- and sound-speed varies discontinuously in the vertical. (This sort of straight-stepped representation of aerological data is customary in meteorological practice.)

The interfacial discontinuity of wind- and sound-speed can be of three sorts. 1) An abrupt increase in the lapse-rate of a ray-returning sounding may be considered as a plus change or a positive discontinuity. (Ray-returning soundings have a negative lapse-rate.) 2) On the other hand, an abrupt decrease in the negative lapse-rate can be referred to as a minus change or a negative discontinuity. Rays penetrating an interface at which the sounding lapse changes from negative to positive locally cease being returned to the ground; instead, they are bent outward into space. Such an abrupt change in the lapse-rate from negative to positive is a local maximum in the sounding curve of wind and sound. 3) This third sort of change may be referred to, then, as a local max.

These three sorts of discontinuities in the (linearized) sounding lapse-rate yield corresponding discontinuities in the radial ranging of sound ray-tubes and hence of sound intensity received. Along an azimuth, the ranging discontinuity of a ray shows up as an abruption in the rate at which the range-distance r changes with increasing the inclination φ at which a ray initially departs from its source; viz., $dr/d\varphi_o$.

Through a homogeneous medium and outward from a continuous point source, the sound energy would propagate uniformly in all directions normal to spherical surfaces of constant phase. But,

in the anistropic atmosphere, such propagation must of course be modified, somehow. The modification shows up as local intensifications (and diminutions) in the propagated field of sound intensity -- sound foci, etc.

In practice, a modifier is therefore used to dialate or diminish (in a way properly attending to the particular structure of the atmosphere) the spherically propagated sound energy. The modifier is, of course, the non-dimensional focusing factor. At the landing point of a returning ray, it is its individual focus-factor; at selected locations, the total focus-factor of all rays arriving there.

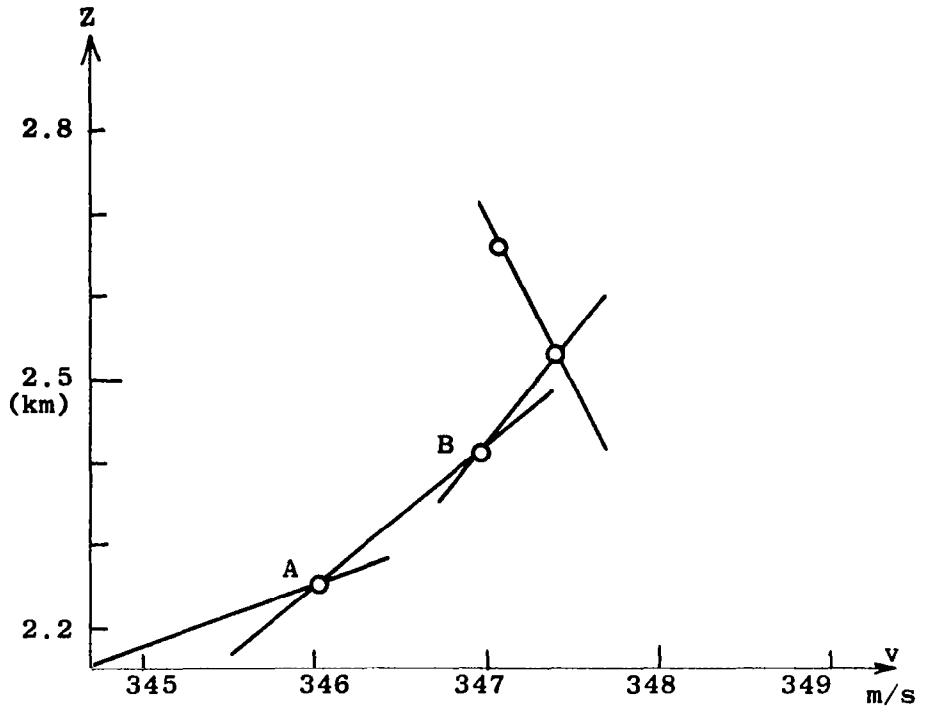
The focus-factor varies inversely with $dr/d\varphi$. Hence, negative lapse-rate discontinuities at data-points along a linearized sounding each create somewhere a sound focus, a false focus.

In part, then, the results of the numerical exercise to be presented here is a quantification about the nature of these false foci and their elimination. The presentation shall now start out with the first mentioned sort of discontinuity.

B. POSITIVE DISCONTINUITIES IN THE LINEAR SOUNDING

Two examples of the first mentioned sort of discontinuities in the sounding lapse-rate (and $dr/d\varphi_o$-function) will be shown first.

The upper part of Figure 14 is a portion of the sounding of wind- and sound-speed, $v=u+c$, for 29 January 1964, 1610 CST, at Huntsville. The data points, represented by small circles, are joined by intersecting, straight lines. The data-points A and B are positive discontinuities in the sounding.



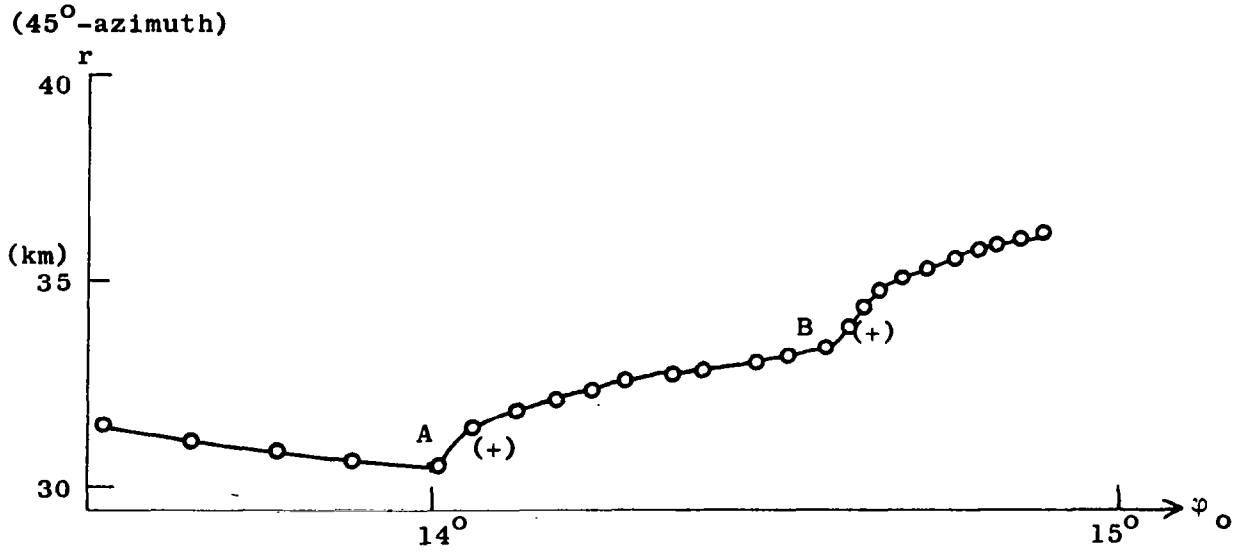


FIGURE 14

29 January 1964

The lower part of the figure shows the variation of the function $r=r(\varphi_o)$; with the initial inclination angle increasing along the horizontal to the right and the radial distance of the returning ray increasing upward. The ray-zeniths at points A and B are the heights at A and B in the upper figure.

With increasing initial-inclination, the slope of the plotted $r(\varphi_o)$-curve abruptly backs (i.e., turns counterclockwise) at points A and B, from slightly negative to positive at A and from slightly positive to increasingly positive at B. There, the discontinuity in $dr/d\varphi_o$ is positive, as indicated by the signs in the figure. Partly because of the pronounced negative lapse-rate of the sounding curve in this case, the magnitude of these discontinuities is relatively small, as compared, for example with those in the next case.

In Figure 15, the main part shows the variation in the function $r=r(\varphi_o)$ for both the linear and parabolic representation of the sounding curve on 13 March, 1633 CST, at Huntsville. Without encircled points, the continuous $r(\varphi_o)$-curve of the parabolic representation is smooth; whereas, the dashed one for the linear representation has very pronounced discontinuities in its slope, $dr/d\varphi_o$, at the data points B, C, and D.

In the upper-middle part of the figure, the inset graph presents the linearized sounding curve of wind- and sound-speed, the coordinates being the same as in Figure 14. Only that section of this sounding curve corresponding to the $r(\varphi_o)$-function curve shown below is presented in the inset -- a section around a relatively high altitude of 10,000 ft. As can be observed, positive discontinuities in the lapse rate of wind- and sound-speed occur at the data points, B, C, and D.

For the linear representation at these data points, the slope of the $r(\varphi_o)$-curve has pronounced discontinuities, as can be seen

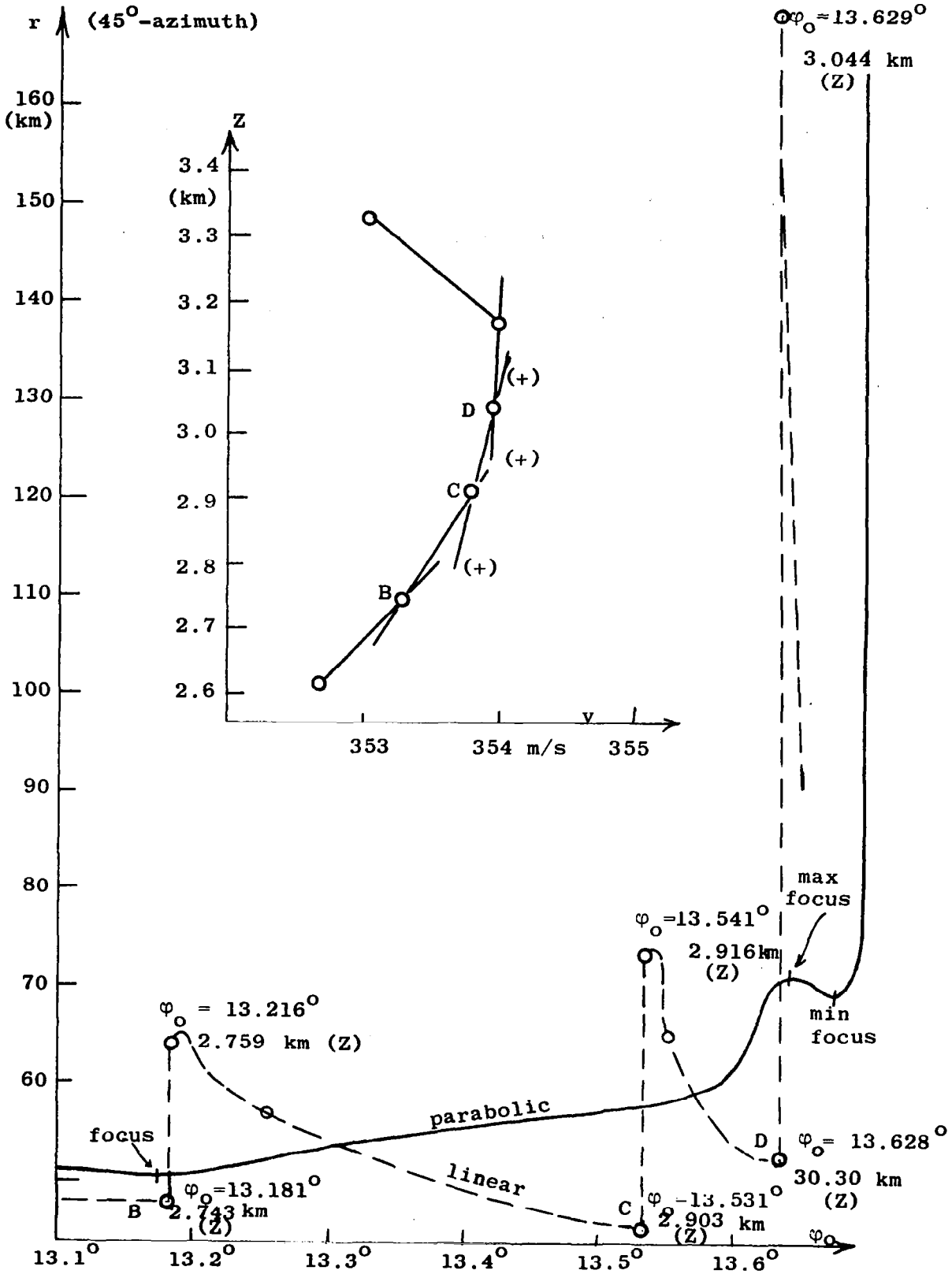


FIGURE 15

13 March 1964

in the main part of the figure. Here, the slopes change from being slightly negative to steeply positive.

To give evidence that the seemingly vertical segments actually slope positively, the φ_o-values are plotted at the terminals of these segments. For the data points B, for example, the φ_o-values increase from 13.181^o at the lower end to 13.216^o at the upper end. On the $r(\varphi_o)$-curve for the linear representation, moreover, the ray-zeniths (in kilometers) are also plotted, just beneath the φ_o-values. For the value of the $r(\varphi_o)$-function at C, for example, the corresponding ray is the one that started out with an initial inclination of 13.531^o and topped out at a zenith altitude of 2.903 km. As can be seen in the inset, this altitude corresponds to the interfacial surface between linearized layers at C.

In Figure 15 the upper ends of the nearly "vertical" segments also bear the plotted values of the topping-out height of the rays, the initial-inclinations of which are also plotted there, just above the zenith values. This sort of evidential care is perhaps belabored here a bit; for, later, there will be encountered such segments which are exactly vertical in the representation be given in this report. The latter segments represent different physical considerations (local maxima) in the sounding curve of wind and sound.

As in Figure 14, then, positive discontinuities of $dr/d\varphi_o$ in Figure 15, occur with positive discontinuities in $-dv/dz$. But, Figure 15, demonstrates the fact that no such discontinuities occur in the $r(\varphi_o)$-curve for the parabolic representation.

Incidentally, the $r(\varphi_o)$-curve for the parabolic representation also illustrates the definition of the so-called "max-" and "min-" foci. As seen, a max-focus occurs out at a range of 71.2 km for the ray having an initial inclination of 13.636^o. On the other hand, two min-type foci occur at a distance of 51.137 km

(for an initial inclination of 13.174^{o}) and 68.990 km (13.674^{o}).

As a precautionary reminder, it is mentioned that "min-" and "max-" here are not descriptive of the focal intensities: For a min-focus, the ray-range trends first inward toward the sound-source but then back outward; for a max-focus, the ray range trends outward from a range reference and then inward and again past that range reference on toward the sound source. (In Sub-routine TENSITY, arithmetic statement 560 defines exactly this meaning, which is articulated out in the code by arithmetic statements 627, 628, and 629.)

Before finally leaving Figure 15, mention can be made of an additional property represented there, that of the infinitely ranging ray at a local maximum in the parabolic sounding curve. For the parabolic representation the $r(\varphi_o)$-curve is seen to go upward at the right. This variation corresponds to ranging of the ray topping out at the local maximum in the parabolically represented sounding, not shown. For the linear sounding, the inset diagram show the local maximum as the point just above data-point D. Fitted to the data-points shown there, the parabolic sounding would have its local maximum between the mentioned points; viz., at 31.22542 km, with a maximum value of v=c+u of 354.009 meters per second.

The main purpose intended by Figures 14 and 15 is numerically to verify that positive discontinuities in $dr/d\varphi_o$ correspond to positive discontinuities in -dv/dz. In the following cases, minus discontinuities in the sounding lapse-rate of wind and sound will be considered.

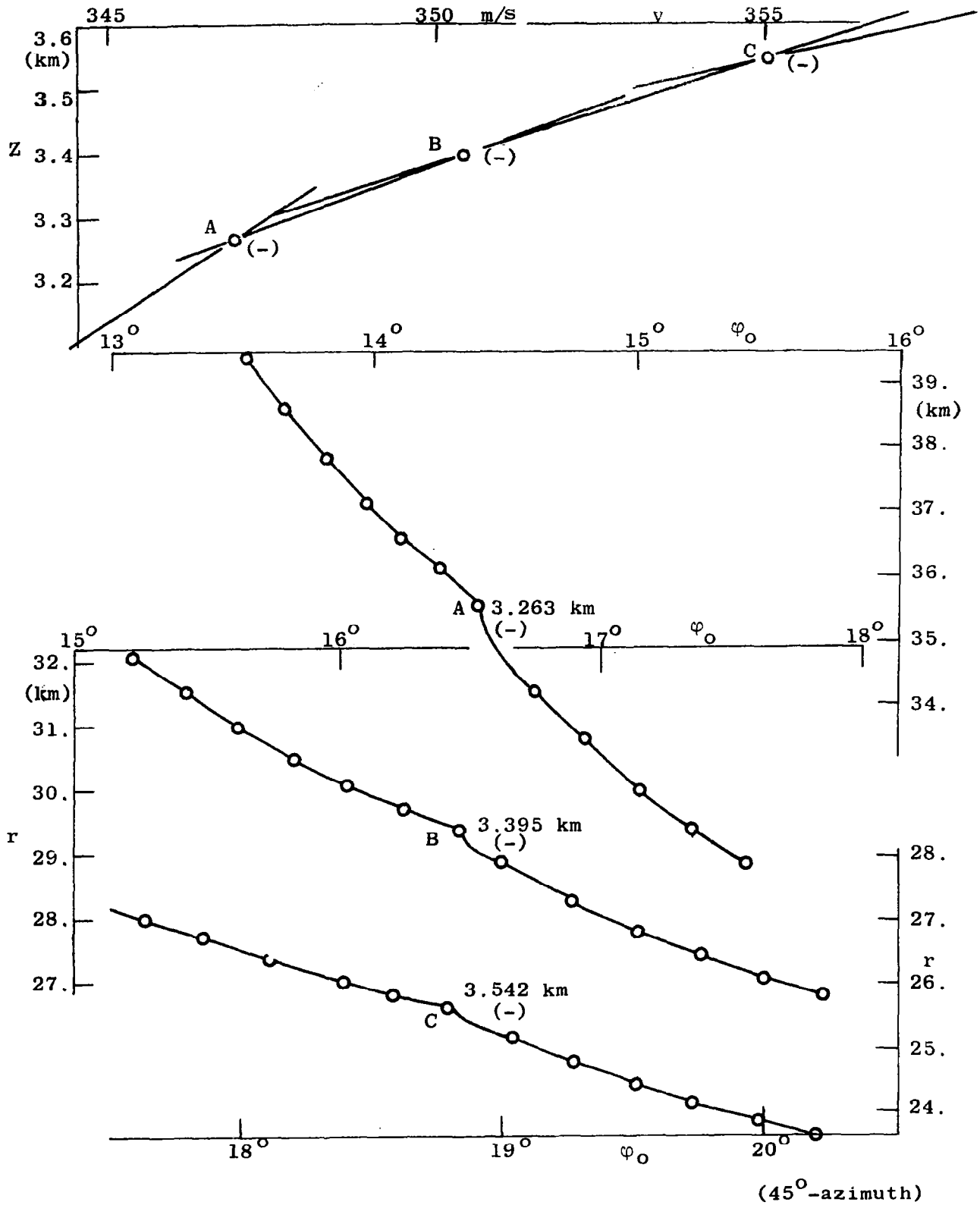
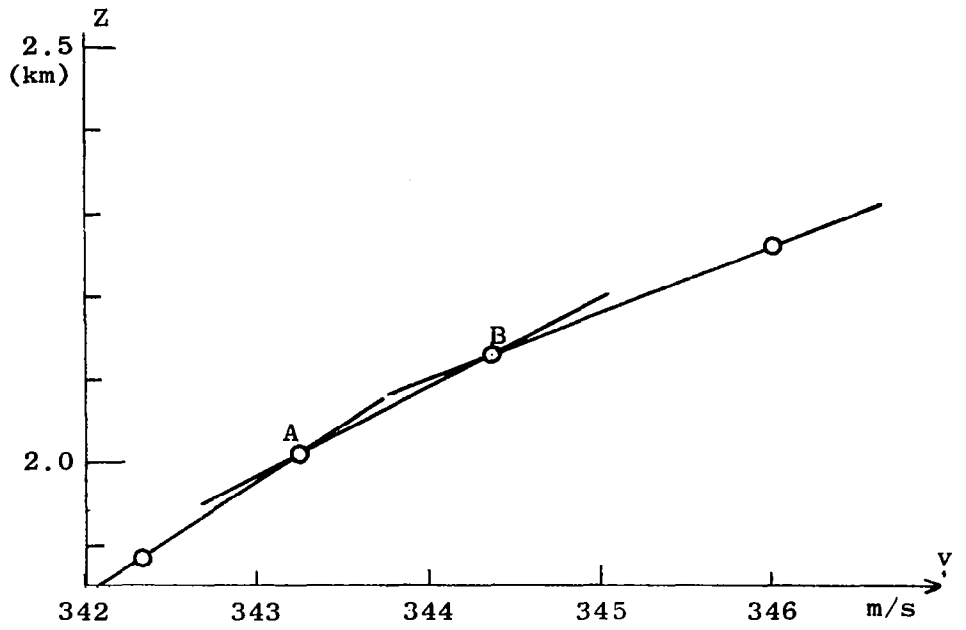


FIGURE 16

13 February 1964



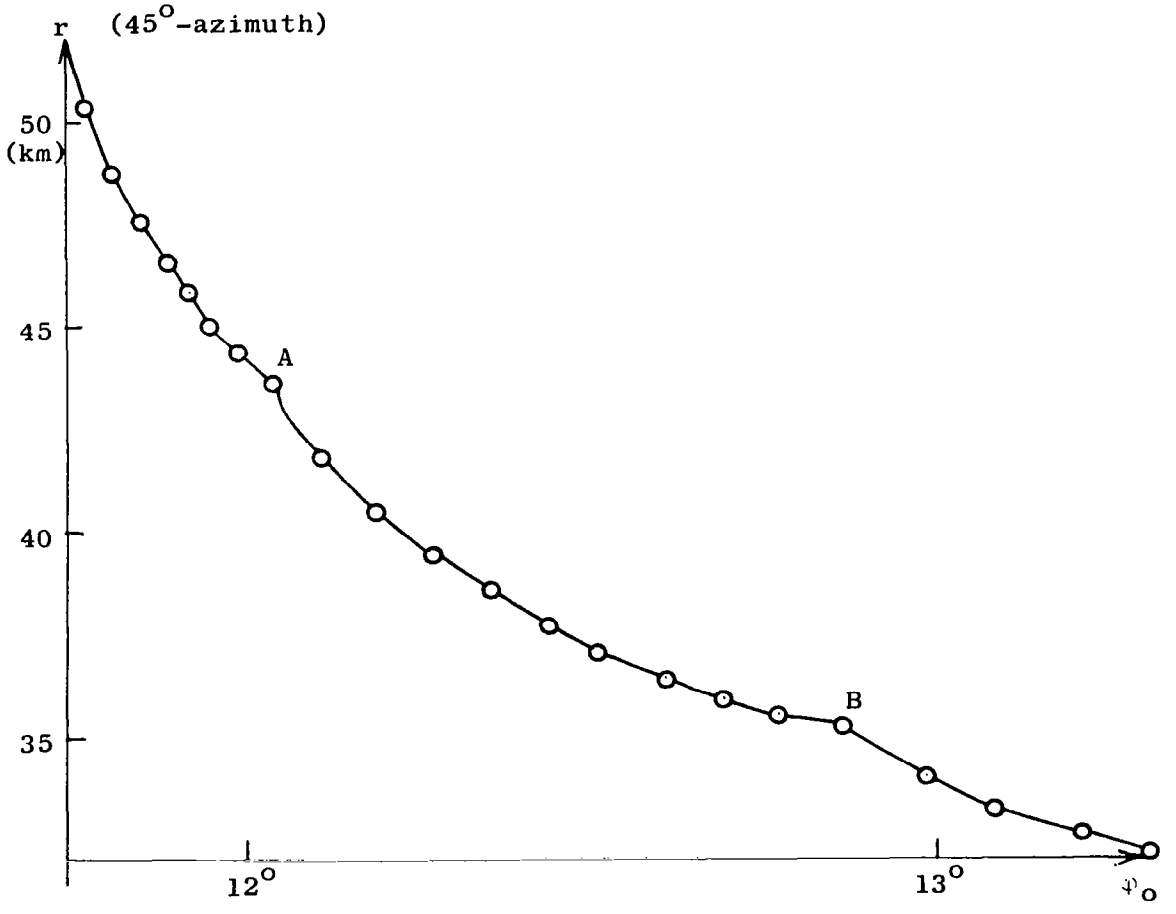


FIGURE 17

29 January 1964

C. NEGATIVE DISCONTINUITIES IN THE LINEAR SOUNDING

Figure 16 attempts to compare four graphical representations. For the top curve the coordinates appear at the top and the left; for the bottom curve, at the bottom and right. The upper middle curve has its coordinates at the right and above; while, the lower middle curve, at the left and above. The top representation is a section of the sounding curve for 13 February 1964, 1639 CST, at Huntsville; the other three are sections of the $r(\varphi_o)$-curves corresponding to the three data points shown in the sounding curve (top). The coordinate units and representations are the same as in Figures 14 and 15, before.

As indicated parenthetically by minus signs, negative discontinuities occur in the sounding lapse-rate at data points B, C, and D. At these corresponding points in all three $r(\varphi_o)$-curves, there is a negative discontinuity in $dr/d\varphi_o$; with increasing initial-inclination, the slope changes from negative values to increasingly negative values. Ray zeniths are plotted at these break-points in the $r(\varphi_o)$-curves; these zeniths are the same as the height values of data points (on the sounding).

For the atmospheric sounding on 29 January, 1964, 1610 CST, at Huntsville, the selected portions of the curves shown in Figure 17 show the same sort of result; viz., that negative discontinuities in the lapse-rate of the linearly represented sounding yield negative discontinuities in the slope of the $r(\varphi_o)$-curves.

Whereas in Figure 17 $dr/d\varphi_o$ breaks negatively with apparently small changes, such breaks can also be actually as large as those positive breaks shown in Figure 15. For example, Figure 18 shows such a large break, at point B. Figure 18 shows a portion of the

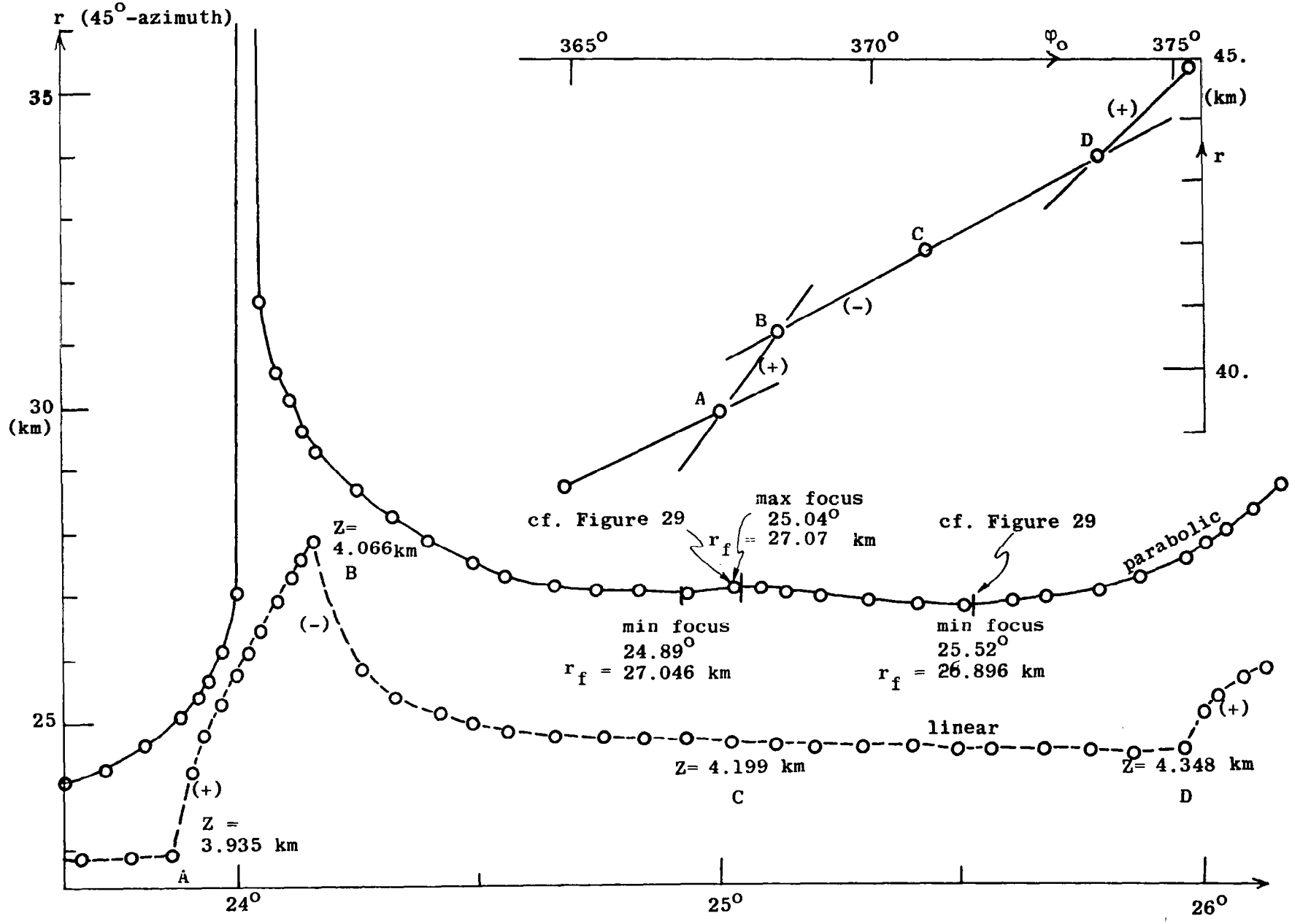


FIGURE 18

13 February 1964

sounding curve (inset at upper right) and the corresponding $r(\varphi_o)$-curves (the main part of the figure) for the atmospheric conditions on 13 February 1964, at 1639 CST, at Huntsville. The coordinates are like those of the preceding figures. The dashed lower $r(\varphi_o)$-curve results from the linear representation of the sounding shown in the inset; the continuous upper curve, from its parabolic representation, not shown.

In the linear $r(\varphi_o)$- and v-curves, paired points A, A and D, D have positive discontinuities in $-dv/dz$ and $dr/d\varphi_o$, in accordance with the results already shown in Figures 14 and 15. Paired points B, B have pronounced negative discontinuities. There (at B), in the $r(\varphi_o)$-curve, the slope changes abruptly from steeply positive to steeply negative, with increasing initial-inclination. But, paired points C, C give little evidence of such discontinuities. Plotted at the points along the $r(\varphi_o)$-curve for the linear representation of the sounding, the ray zeniths are numerically the same as the heights of the data points indicated along the sounding, to the inset.

Also shown for comparative purpose in Figure 18 is the $r(\varphi_o)$-curve resulting from the parabolic representation of the sounding on this occasion, the continuous middle curve in Figure 18. First of all, it can be seen that none of the three linearly produced breaks occurring in the slope of the linear $r(\varphi_o)$-curve appear in the parabolic $r(\varphi_o)$-curve. On the other hand, as indicated, three true foci appear in the parabolic representation. (Around and at two of these three foci, the distribution of the sound intensity is shown in Figure 29, as well as that resulting from the linear representation for the same condition —— all of which will be discussed later.)

But, the linear representation yields no foci in the range interval, indicated along the vertical in Figure 18. To be sure, min-type sound amplifications appear at ranges corresponding to the points A and D (points A and C in Figure 29); as well as a max-type, corresponding to B. But, these are false foci, artificially created by the linearization of the sounding.

The third sort of change will now be considered, that having been referred to as the local max.

D. LOCAL-MAX DISCONTINUITIES IN THE LINEAR SOUNDING

In connection with Figure 15, it was mentioned that a special effort should be given to recognizing the small, apparent difference between nearly vertical and truly vertical segments in the $r(\varphi_o)$-curve, resulting from the linear representation of the sounding curve. This effort was made by plotting values of the initial inclination and the zenith for the rays (or ray) corresponding to the ends of these $r(\varphi_o)$-curve segments. Such recognition appears in Figure 19 which shows $r(\varphi_o)$-curves associated with a local maximum in the sounding of wind and sound.

In Figure 19, the schematics are as in the previous figures. The lower-right inset presents a portion of the sounding curve, while the main part shows the distribution of the $r(\varphi_o)$-function. Only, here, in order to show the extreme ray-ranges involved and still preserve some detail in the shape of the discontinuities also involved, a middle range of some 35 km in ray travel distance has been cut out of the figure, as the horizontal scallops have been intended to suggest.

(By now, the paired points A, A are easily recognizable as associating positive discontinuities in the lapse-rate of the linearly represented sounding and in $dr/d\varphi_o$. But, . . .)

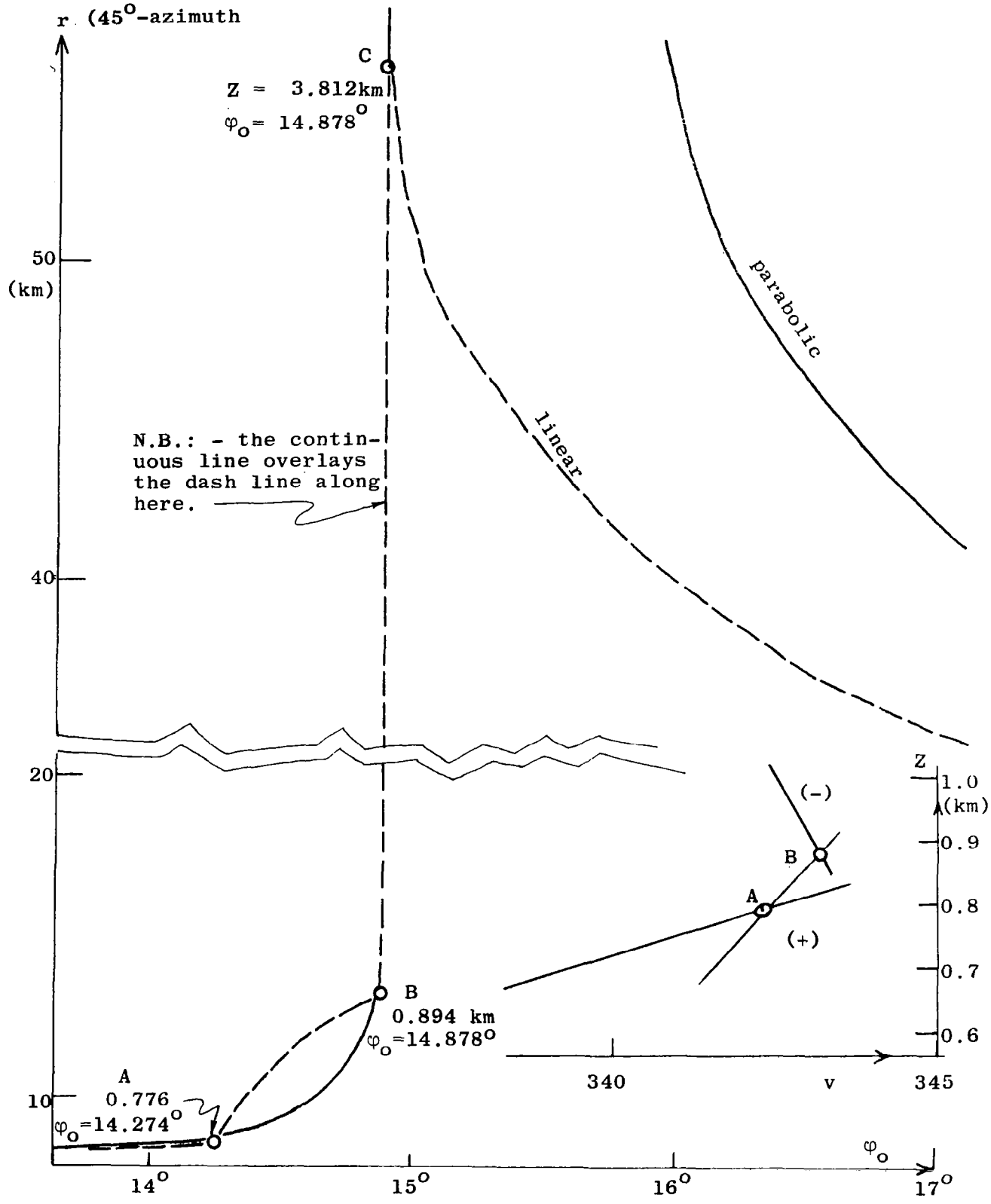


FIGURE 19

27 February 1964

Paired points B, B represent the main consideration of this figure. In the sounding curve, B is a local maximum in wind- and sound-speed, v. In the corresponding $r(\varphi_o)$-curve B represents the ray (having the initial inclination of 14.878^o) that horizontally tops out at 0.894 km, which is also the height of the data-point at the local maximum in the sounding curve. In other words, this ray has its zenith at the top of the atmospheric layer AB; it returns to the ground at a range of 13.085 km, a value that may be interpolated from the left ordinate of the figure.

In the main part of Figure 19, consider now the "ray" corresponding to the upper point C, with coordinates of 3.812-km range and 14.878^o initial inclination. That its inclination is the same as for the ray at the lower point B indicates, first of all, that the $r(\varphi_o)$ curve-segment BC between them is vertical. But, that its range is different by some three kilometers reveals that the initial ray has bifurcated itself at the level B. One "part" of the ray has topped out at the level B and thereafter returned to the ground; whereas, the other "part" has been "bent" upward, penetrating the atmospheric layers above level B, before having encountered superjacent layers (not shown) again having negative lapse-rates of wind and sound that enable the return of the other bifurcated "part" of the ray to the ground, 3.812-km from its source.

With initial-inclination increasing from the left, the slope of the $r(\varphi_o)$-curve at B is positive. But, at the upper point the slope is very steeply negative with increasing initial-inclination toward the right. Thus the change in slope at B is abruptly negative -- from a moderate plus-value to a rather large negative-value. This case thus illustrates the generalization made in the previous report that $dr/d\varphi_o$ is negatively discontinuous at a local maximum in the linearly represented sounding of wind- and sound-speed.

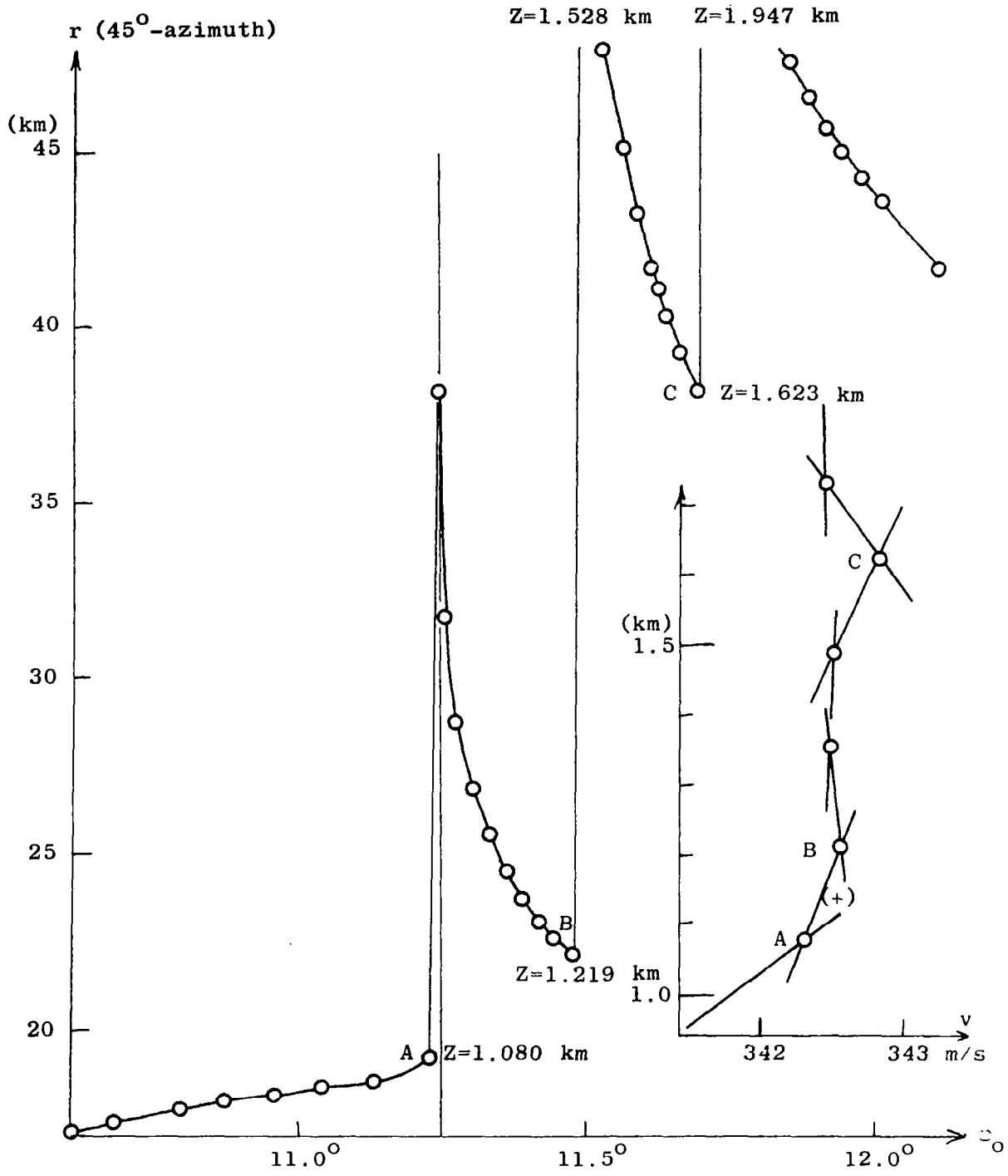

r (45°-azimuth)
(km)
45
40
35
30
25
20
Z=1.528 km
Z=1.947 km
C
Z=1.623 km
B
Z=1.219 km
A
Z=1.080 km
(km)
1.5
1.0
C
B
(+)
A
342
343 m/s
11.0°
11.5°
12.0°

FIGURE 20

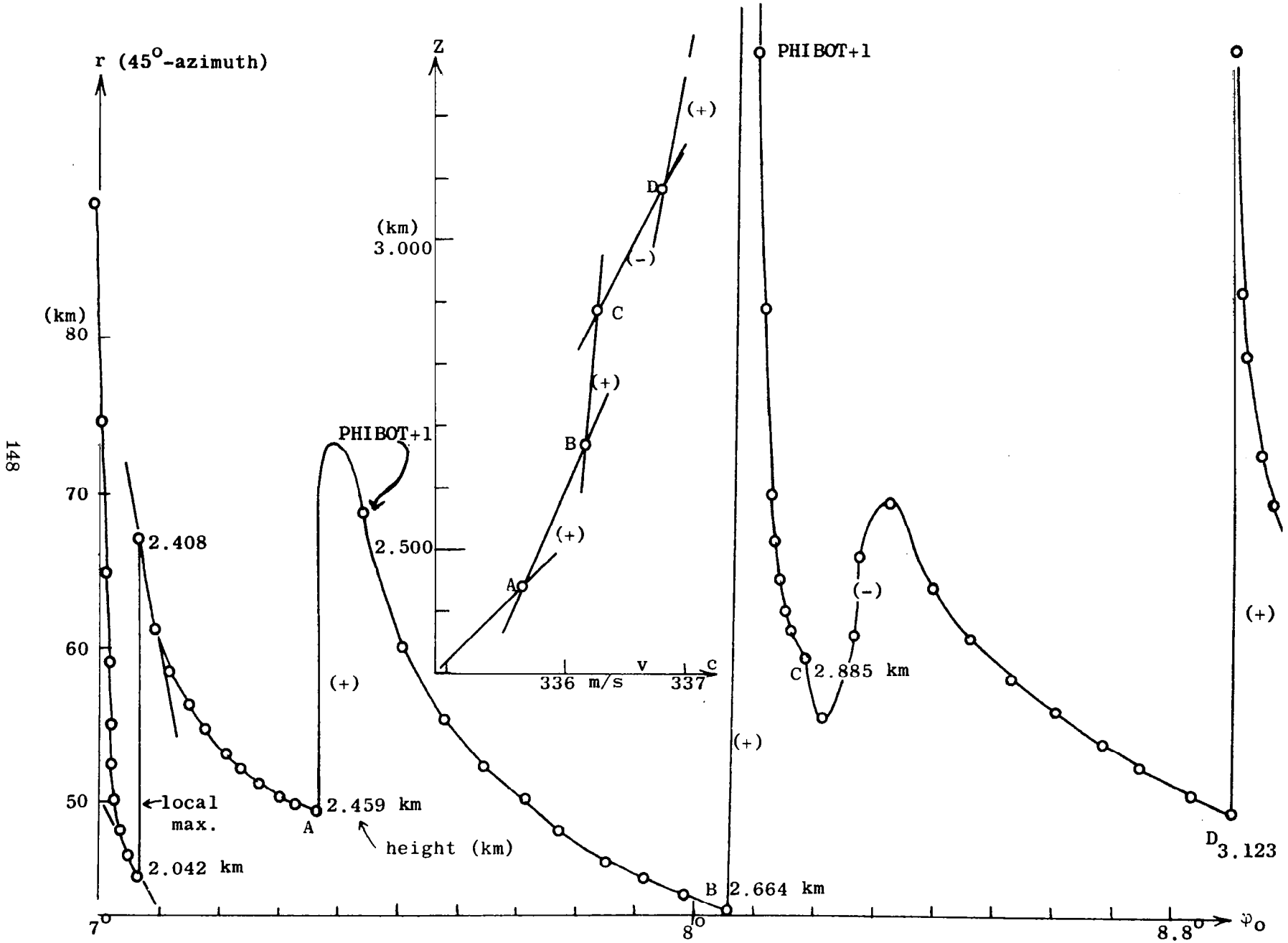


FIGURE 21

The Sign of the Discontinuity in $dr/d\varphi_o$ at Data Points (large curve) corresponding to that in dv/dz (inset) of the Linearized Representation of the Atmospheric Sounding on 10 January 1964, 1636 CST, at Huntsville.

In this particular case, the local maximum in the parabolic sounding (not shown) is at 896.223 meters, very close (within 2.2 meters) to the B-level of .894 km. Corresponding to this max, the $r(\varphi_o)$-curve is shown also in Figure 19. Of course, the ray topping out at this parabolic max ranges infinitely, so that the parabolic $r(\varphi_o)$-curve in Figure 19 has an asymptotic, arms extending indefinitely upward. Two additional examples of the third sort of change -- the local max -- are shown in Figure 20.

Inset in the lower right of Figure 20 is the sounding curve showing local maxima at B and C, as well as a plus discontinuity in -dv/dz at A. In the portion of the linear $r(\varphi_o)$-curve shown, negative discontinuities in $dr/d\varphi_o$ occur at B and again at C. Toward the foot of the B-vertical from the left, for example, the negatively sloping $r(\varphi_o)$-curve is seen to be less steep than that at the top-right of the B-vertical -- even though the join point near there (at a zenith height of 1.528 km) lies above the upward extent of the Figure. The fact that $dr/d\varphi_o$ is negatively discontinuous at C is not convincingly shown in this figure, for the join point (with ray-zenith at 1.947 km) lies about 2.5 inches above the figure

Thus far the sequence of the figures has presented examples of increasing complexity in the ranging properties of rays as a function of their initial inclination angle. More figures continue unfolding this progression.

In Figure 21, from left to right, appear a local max, two positive discontinuities (A and B), a negative discontinuity (C), and a positive discontinuity (D). At 2.042 km altitude, the local max lies below the portion of the sounding shown in the middle inset. Introduced at the ends of the vertical segment of the $r(\varphi_o)$-curve, the tangential lines schematically accent the negative discontinuity in $dr/d\varphi_o$ there.

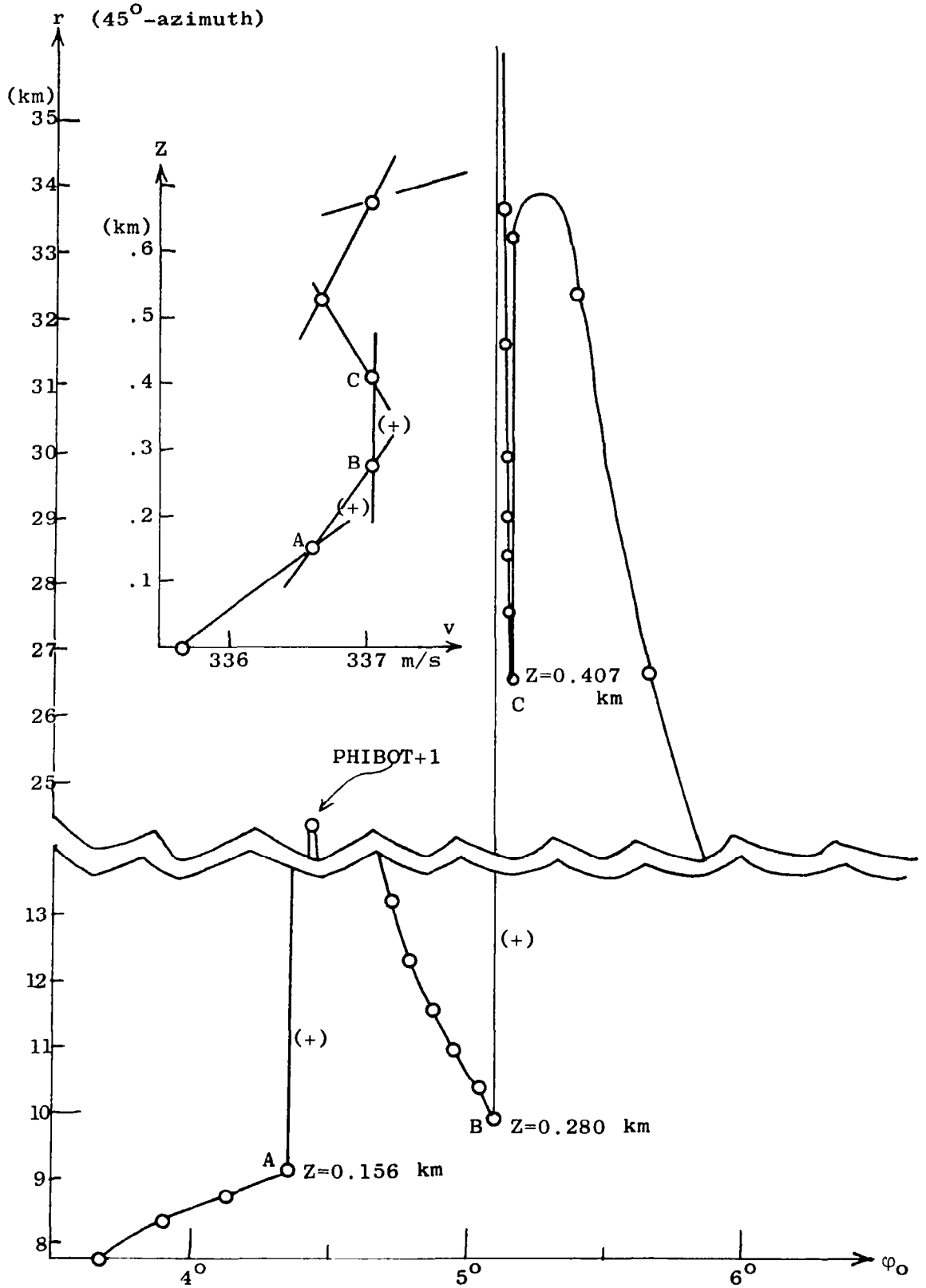


FIGURE 22

29 January 1946

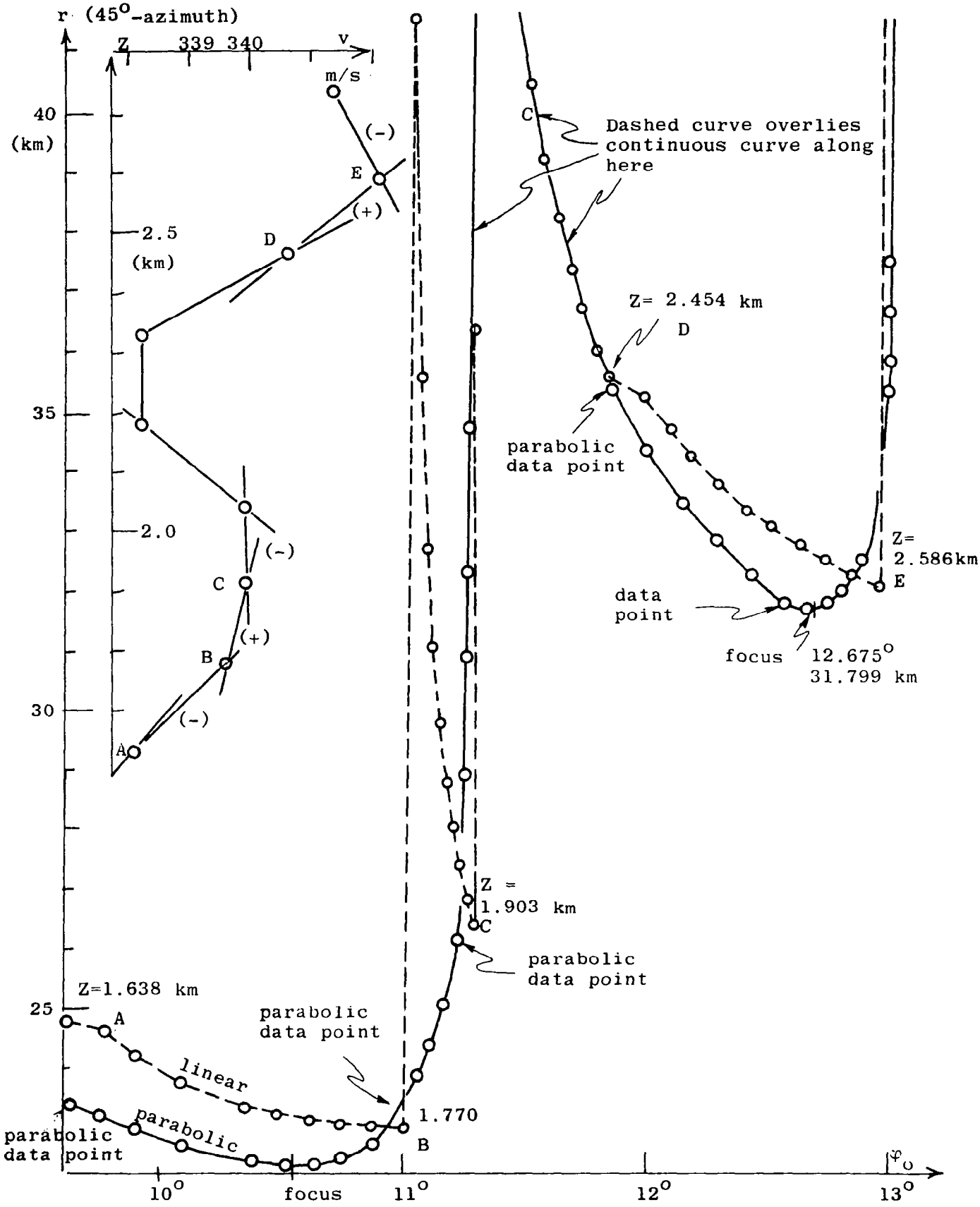


FIGURE 23

13 February 1964

That the positive discontinuity at B is especially pronounced is evident in the nearly vertical negative-slope at the top of the $r(\varphi_o)$-curve descending toward C, with increasing initial-inclination. The expression "PHIBOT + 1" has been introduced to indicate the second from lowest ray in the vertical ray-fan for the layer bounded between the successively labeled data-points. ("PHIBOT" is the "φ_o-bottom" ray.) Other than for max discontinuities, the first ray corresponds to the labeled points on the $r(\varphi_o)$-curve and coincides there with the topping-out ray for the subjacent layer.

In a sense, the points B, C, and D on the $r(\varphi_o)$-curve each represents two rays, the top one of the ray fan for the subjacent layer as well as the bottom one for the ray fan of the next higher atmospheric layer. Actually, of course, both are the one and same ray path, landing at a single point, the range from the source being the ordinate value of that labeled point. —— The lower curve in Figure 12 details out this consideration.

Although fulfilling the generalization pertaining to negative discontinuities in Figure 21, the paired points C, C deserve special attention, for the variation there of the $r(\varphi_o)$-function is of a form different than that having been seen in Figures 16, 17 and 18.

Just as in Figure 19, Figure 22 has been vertically collapsed or accordianed together, by having taken out a mid-range section of some 12 km. In the slope of the $r(\varphi_o)$-curve, positive discontinuities at A and B are easily evident.

In Figure 23, negative discontinuities occur at each of the paired points A, A; positive discontinuities at each of the two paired points B, B and D, D; while, at each of the two local maxima, a negative discontinuity in $dr/d\varphi_o$ occurs, at each of the paired points C, C and E, E -- all in accordance with the announced generalizations.

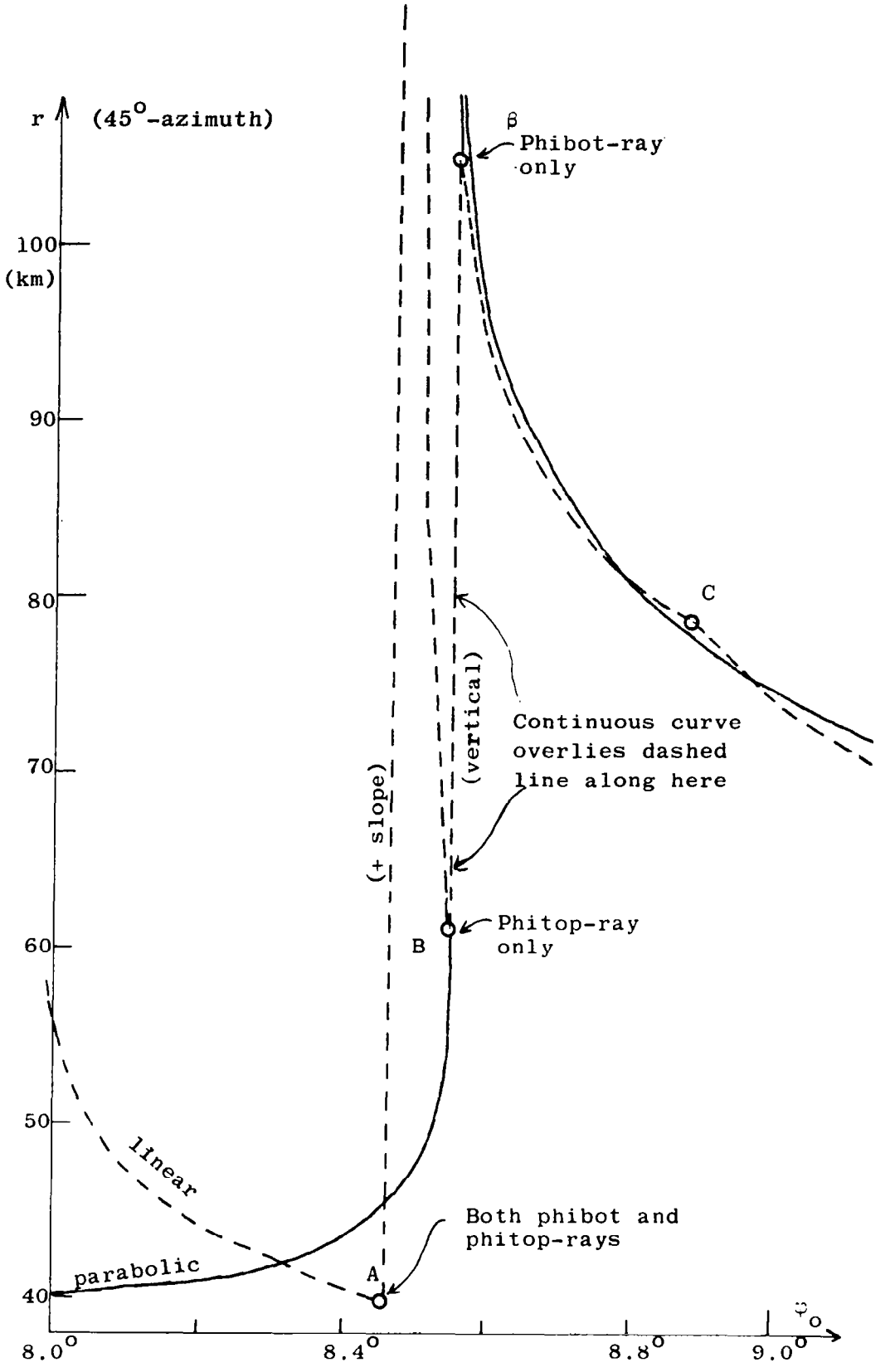

r
(45°-azimuth)
100
(km)
90
80
70
60
50
40
8.0°
8.4°
8.8°
9.0°
φ_o
β
Phibot-ray only
C
Continuous curve overlies dashed line along here
(vertical)
(+ slope)
Phitop-ray only
B
A
Both phibot and phitop-rays
linear
parabolic

FIGURE 24

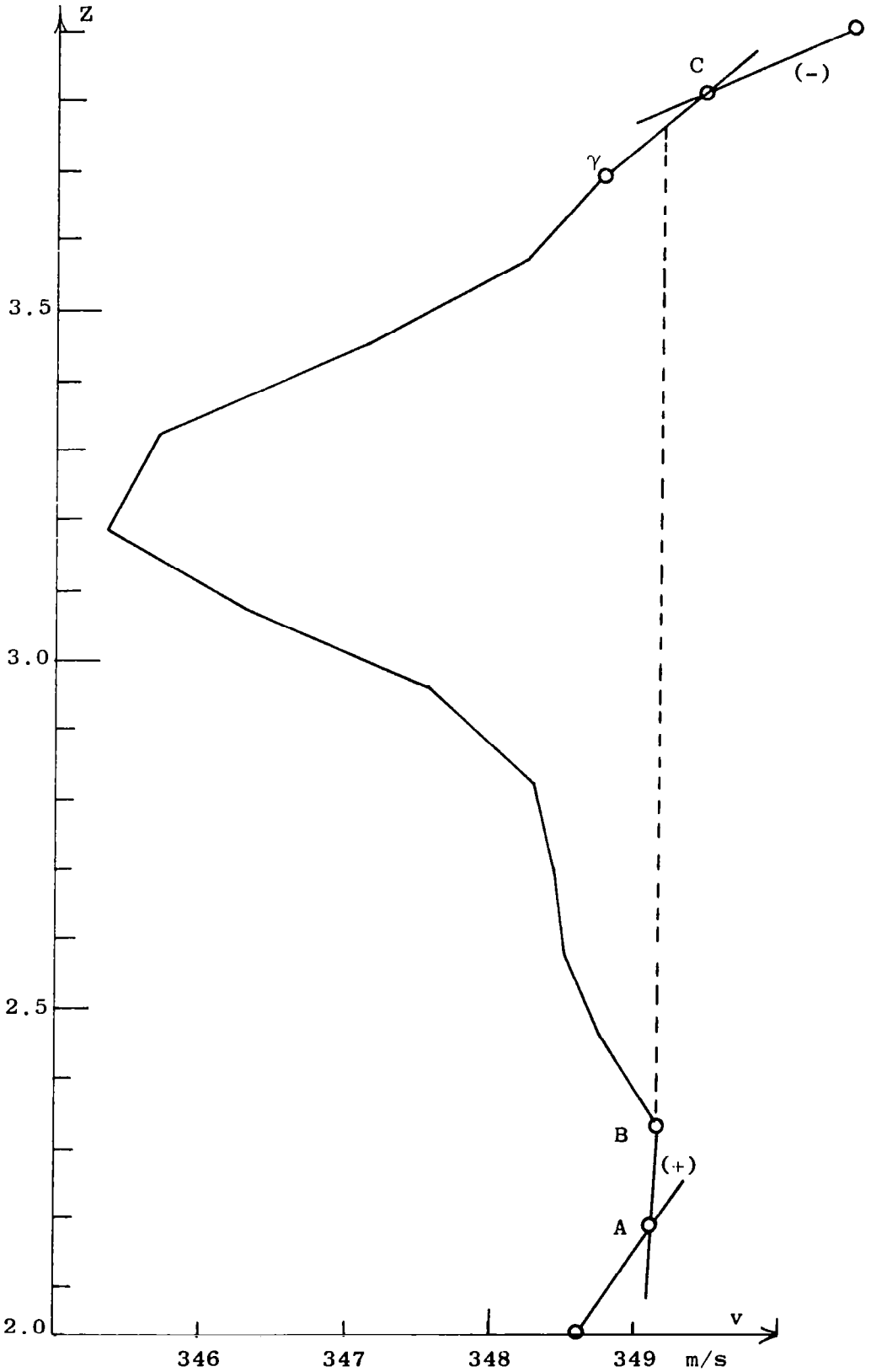


FIGURE 25

20 March 1964

But, none of these five discontinuities appear in the continuous $r(\varphi_o)$-curve that results from the parabolic representation of the sounding. Instead this curve is continuously smooth; moreover, it has the desired additional property that, with incrementation (along the abscissa) in the initial-inclination of the rays, they range infinitely out (along the ordinate) as their zenith approach the levels of local maxima.

Finally, for the parabolic representation of wind- and sound-speed along the local vertical, the corresponding $r(\varphi_o)$-curve properly accounts for two, min-type foci. One is 22.403 km out from the sound-source, for the rays initially inclined at 10.555^o; the other 31.799 km out for rays initially inclined at 12.675^o. The linearly represented sounding, however, is unable to account for any foci at all in the 20-km range interval considered in Figure 23.

Figure 24 presents an example of each of the three mentioned, different types, and Figure 25 is a portion of the linear sounding curve for the occasion from which these examples are taken, at 1618 CST on 20 March 1964, at Huntsville. They are: A positive discontinuity in $dr/d\varphi_o$ due to a positive discontinuity in the v-sounding lapse-rate (paired points A,A in Figures 24 and 25), negative discontinuities in $dr/d\varphi_o$ at a local max in the sounding (pairs B,B) and a negative discontinuity in -dv/dz respectively (pairs C,C). As before, they are borne out clearly in these two figures.

In Figure 25, the top of the vertically dashed line locates above the local max B the base of the first and next higher partial-layer able again to return the rays back to the ground. In Figure 24, the point β corresponds to the bottom-ray of that partial layer, a ray initially inclined at 8.509^o that ranges out to 104.683 km (values that come respectively from the abscissa and ordinate of β in Fig. 24) and that tops out at the 3.756-km level (from the ordinate of Figure 25), the base of this partial layer. Nevertheless in Figure 24, the point B represents the same ray

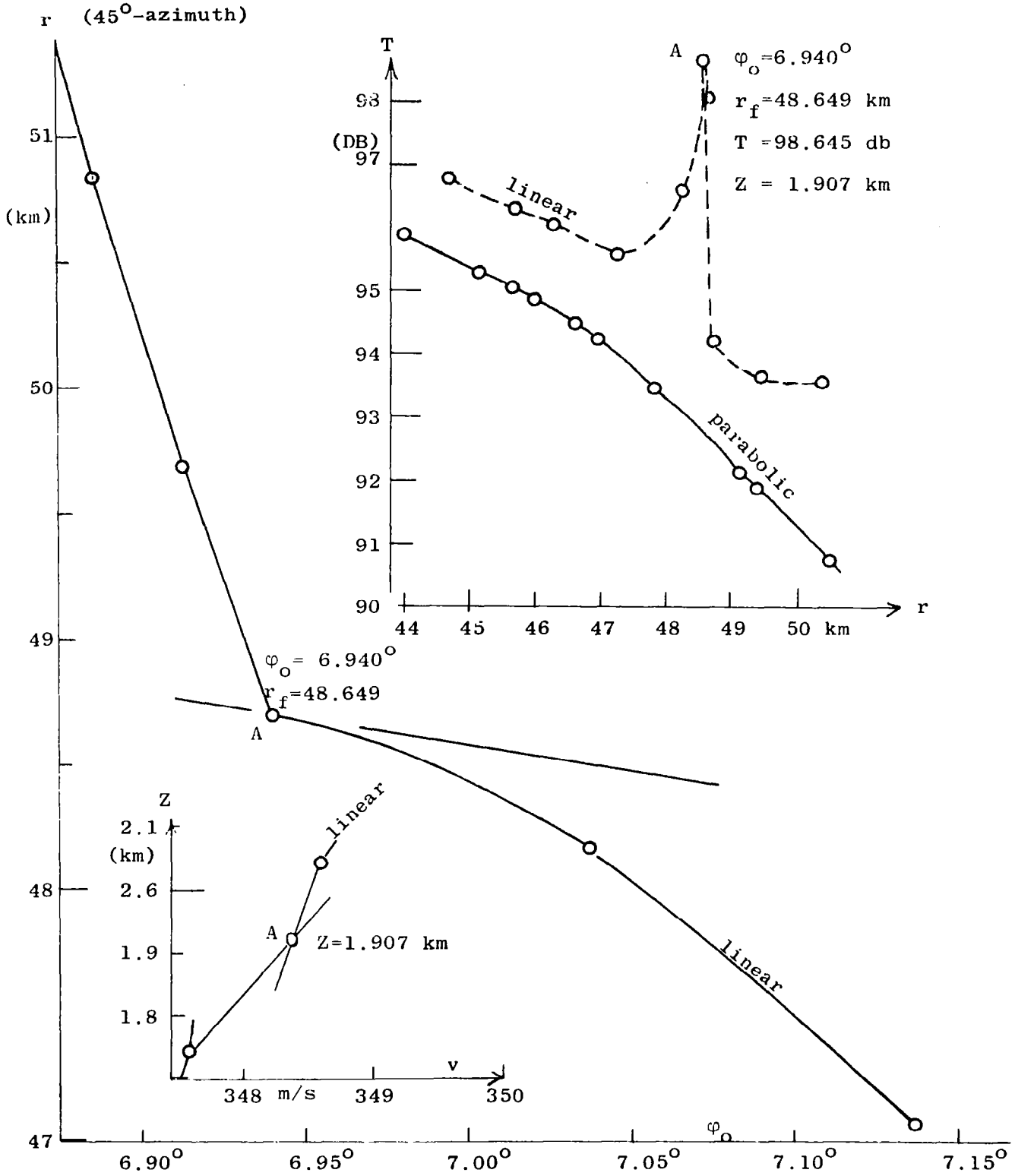

r (45°-azimuth)
51
(km)
50
49
48
47
6.90°
6.95°
7.00°
7.05°
7.10°
7.15°
φo
T
98
(DB)
97
95
94
93
92
91
90
44
45
46
47
48
49
50 km
r
A
φo=6.940°
rf=48.649 km
T =98.645 db
Z = 1.907 km
linear
parabolic
φo= 6.940°
rf=48.649
A
Z
2.1
(km)
2.6
1.9
1.8
linear
A
Z=1.907 km
v
348 m/s
349
350
linear

FIGURE 26

(inclined initially at 8.509°), but bifurcated by having topped out at the 2.340-km level of the local max so as to land 61.104 km away from its source (from the ordinate of Figure 24).

In Figure 24, the $r(\varphi_o)$-curve corresponding to the parabolic representation is void of the discontinuities A and C and properly represents the C-discontinuity as an infinitely ranging ray, with rays of ensonification throughout the range between 61.104 km and 104.683 km.

How a linearly represented sounding of wind- and sound-speed effects variation in the $r(\varphi_o)$-function has now been examined numerically. And, the resulting variation has been compared with that associated with the parabolically smoothed representation along the local vertical of the horizontal wind- and sound-speed. It now follows that the distribution of propagated sound intensity and foci should be next considered in terms of these effects and the resulting variation.

E. THE DISTRIBUTION OF PROPAGATED SOUND INTENSITY AND FOCI

As its main part, Figure 26 presents a portion of the $r(\varphi_o)$-curve at 1618 CST on 20 March 1964 at Huntsville. The upper-right insert shows the ranging of sound intensity at the ground corresponding to the rays and their range shown in the main part of this figure. Attention centers upon the positions A,A,A. There the slope of the $r(\varphi_o)$-curve changes abruptly from steeply negative to slightly negative with increasing initial-inclination —— a positive discontinuity in $dr/d\varphi_o$, at 6.940° and 48.649 km.

For this linear representation of the sounding, the ranging of sound intensity shows a focal spike of 98.645 db, 48.649 km out, the grounding point of the ray initially inclined at 6.940°. But for the parabolic representation of the sound, the ranging of sound intensity shows no such a focus (lower curve in inset).

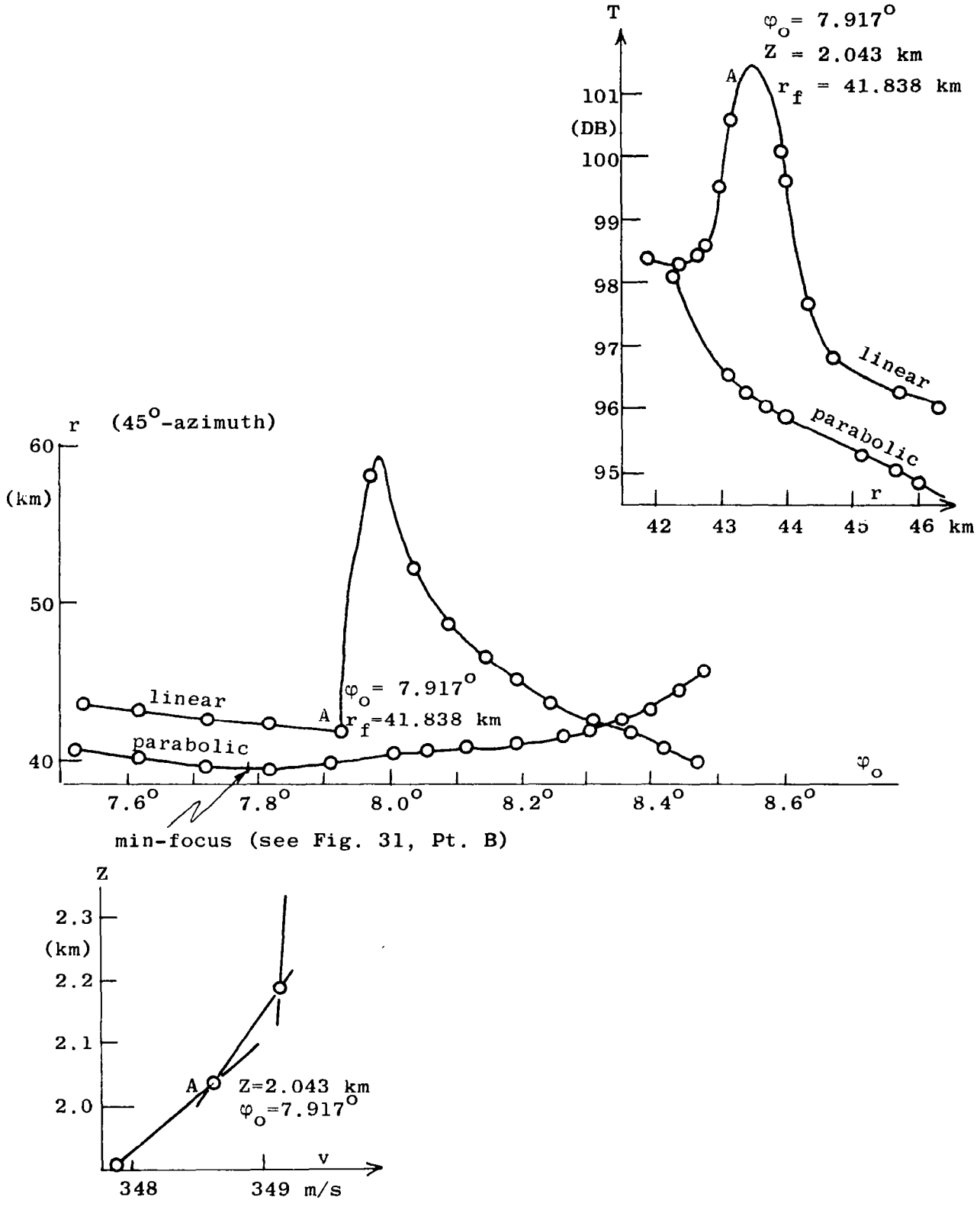

T
φ_o = 7.917°
Z = 2.043 km
r_f = 41.838 km
A
101
(DB)
100
99
98
97
96
95
linear
parabolic
r
42
43
44
45
46 km
r (45°-azimuth)
60
(km)
50
40
linear
parabolic
A
φ_o = 7.917°
r_f=41.838 km
φ_o
7.6°
7.8°
8.0°
8.2°
8.4°
8.6°
min-focus (see Fig. 31, Pt. B)
Z
2.3
(km)
2.2
2.1
2.0
A
Z=2.043 km
φ_o=7.917°
v
348
349 m/s

FIGURE 27

And, on the same occasion (see upper-right insert in Figure 27), the linearly represented atmosphere also produces a 101.5-db focus 41.838 km out, the landing distance of the ray initially inclined at 7.917^{o}; whereas, there is no such focus there for the parabolic representation of the sounding (lower curve). This "linear" focus "A" corresponds with positive discontinuities in $dr/d\varphi_o$ (at A in the middle insert of Figure 27) and in the lapse-rate $-dv/dz$ at the 2.043-km sounding level, the zenith of the ray initially inclined at 7.917^{o} (i.e., at A in the lower-left insert). But, for the parabolically represented sounding, no such discontinuities occur in the $r(\varphi_o)$-curve (lower curve in the middle insert).

The matter may be looked at somewhat differently, as in Figure 28. The main part of this figure identifies the vertically fanning rays according to their initial inclination (abscissa) at the source and the sound intensity at their landings (ordinate). It compares their landing-point intensities obtained from linear and parabolic representations of the sounding curve of wind- and sound-speed, the continuous and dashed curves respectively. Presented in the upper-left inset, the straight-stepped sounding represents the atmospheric condition occurring over Huntsville at 1636 CST on 10 January 1964. A blow-up of that sounding at data-point A is shown in the lower insert. As indicated at that level, the lapse rate has a positive discontinuity, which must be attended by a positive discontinuity in $dr/d\varphi_o$ (not shown). The data-point A is at the 1.643-km level, the zenith of the 2.219^{o}-ray that ranges 25.719 km from the source with a landing intensity of 119.561 db in the linear representation of the sounding. These values are represented by the A-positions in the three parts of Figure 28.

The point to be stressed in Figure 28 is in the difference between the solid and dashed curves: The fan of rays initially

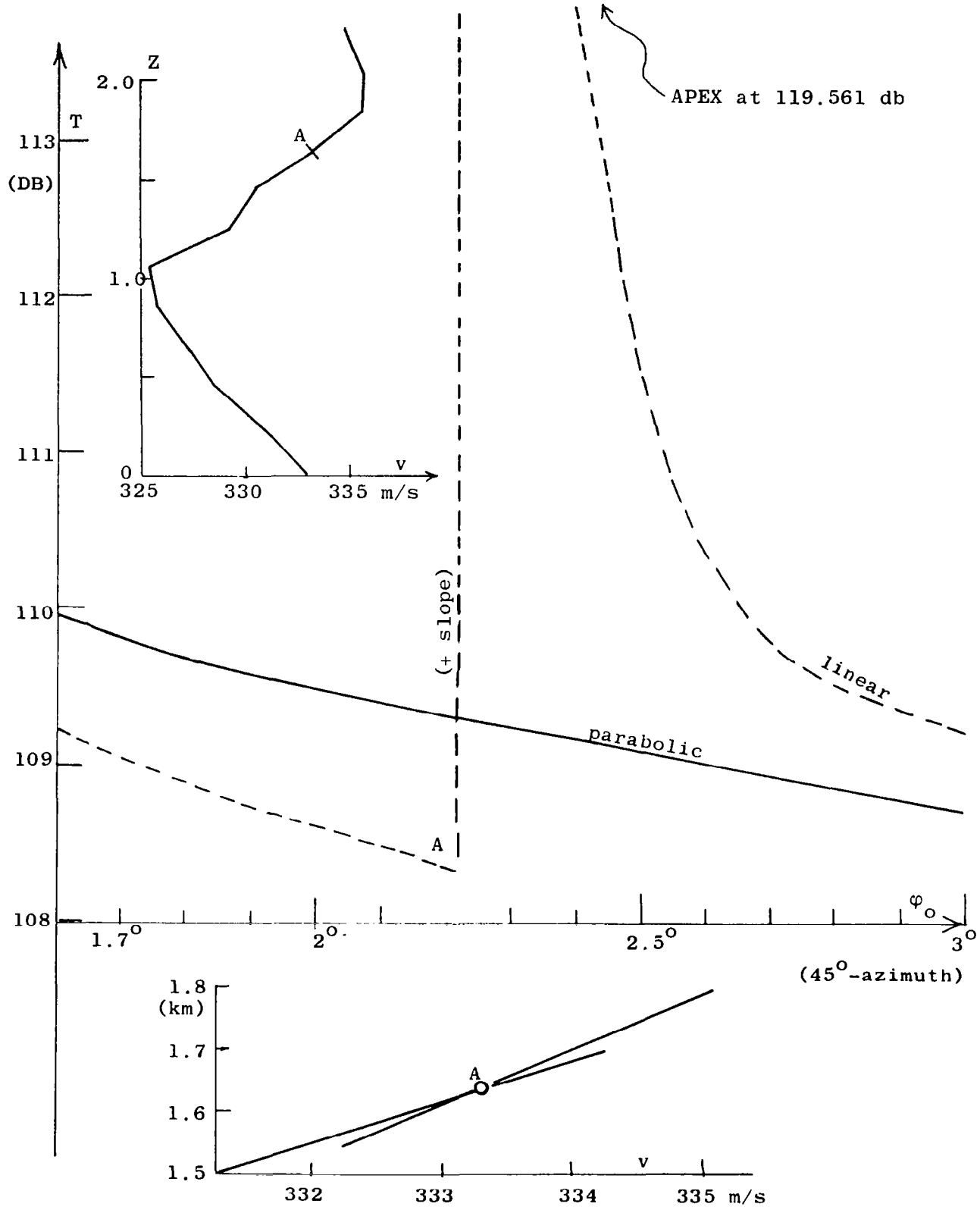


FIGURE 28

10 January 1964

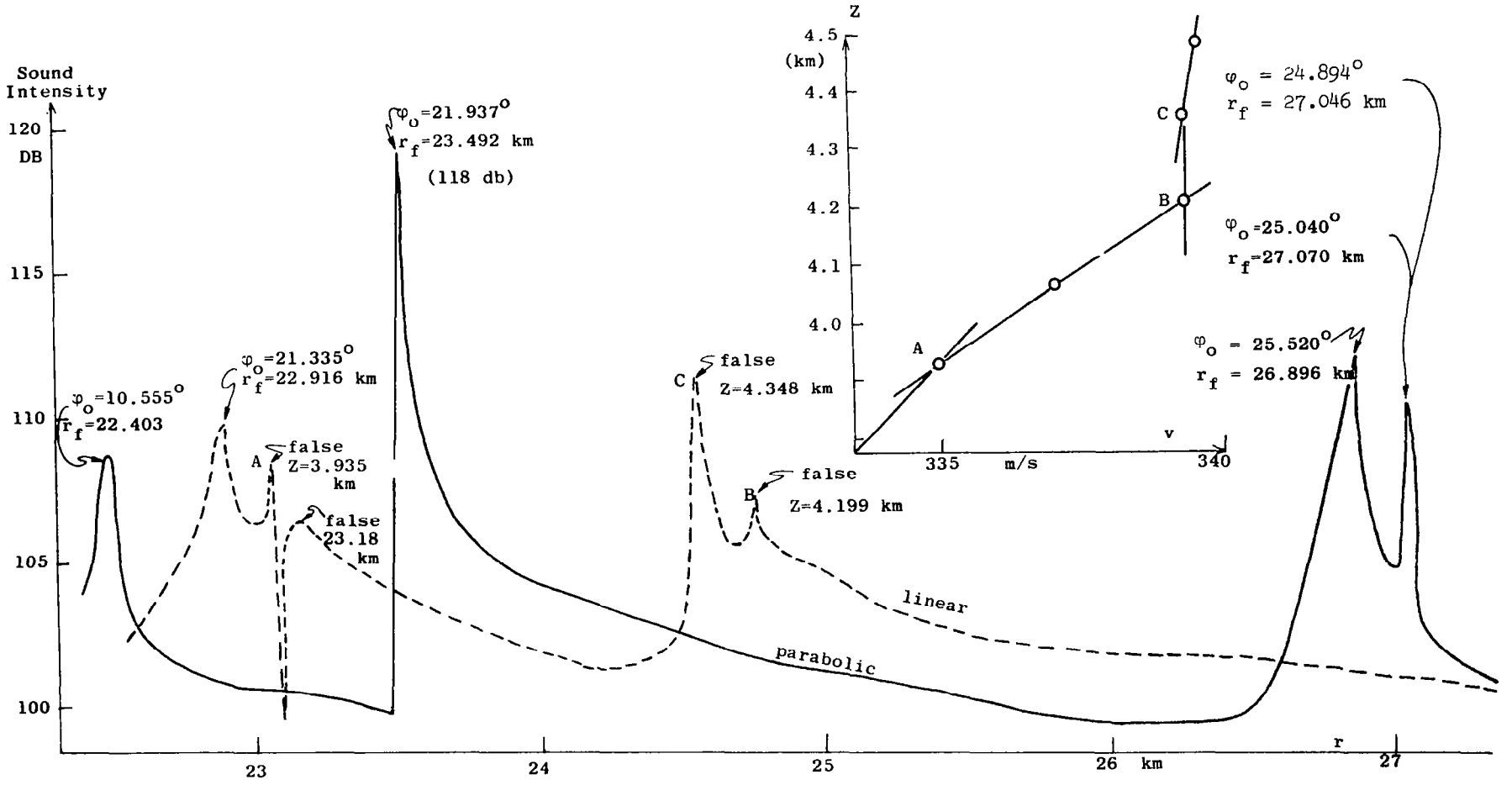


FIGURE 29

(45°-azimuth)

13 February 1964

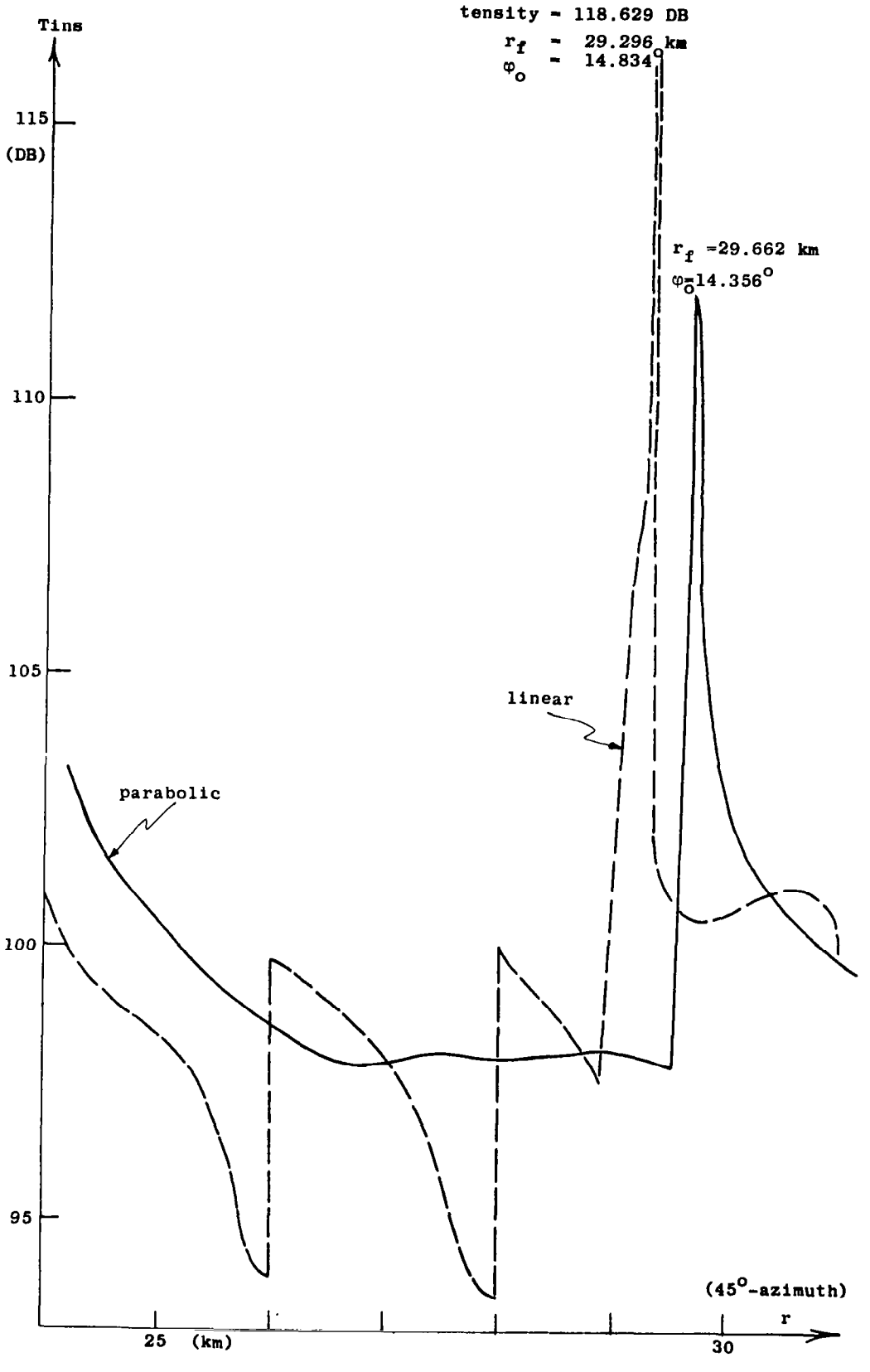


FIGURE 30

7 February 1964

inclined from 1.6^{o} to 3.0^{o} produces no focus in the parabolic representation. That, the 120 db-focus of the 2.219^{o}-ray is falsely created by the linear representation of the sounding.

To some extent, the nature of focal falsification has now been numerically assessed. From that, the discussion can proceed to the crux of the matter; viz., comparing at the ground the azimuthal distribution of sound intensity by the linear representation of the atmospheric sounding with that by the parabolic representation of wind- and sound-speed along the local vertical.

F. REPRESENTATION: LINEAR vis-a-vis PARABOLIC

Figure 29 presents in part the radial distribution of ground-level sound-intensity on 13 February 1964, 1639 CST, along the 45^{o} azimuth from Huntsville. The distribution by the linear representation of the sounding (dashed curve) has three false foci, A, B, and C; which correspond to the data points A, B, and C along the portion of the linear sounding inset in the upper-right of Figure 29. Incidentally, the foci are also earmarked with their range (r_f), ray zenith (Z) -- which is also the data-point level in the linearly represented sounding --- and the initial inclination of the ray (φ_o).

This linear distribution (dashed), nevertheless, does identify a real focus at 22.916 km (the landing of the 21.335^{o} -ray). But, by the parabolic representation, this focus is accounted for as occurring either 23.492 km out, the landing point of the 21.937^{o}-ray, or 22.403 km out (10.555^{o}) -- in either case a difference in azimuthal distance of around two percent.

In Figure 30 is shown another distribution of sound intensity, one occurring on 7 February 1964, 1620 CST, again along the 45^{o} -azimuth from Huntsville (as is the azimuth in all the cases being

January 1968 NASA CR-61187

COMPARISON OF TWO METHODS FOR ESTIMATING SOUND INTENSITY

Prepared under Contract No. NAS 8-11348 by

KAMAN NUCLEAR

For

Aero-Astrodynamics Laboratory

NASA-GEORGE C. MARSHALL SPACE FLIGHT CENTER

PREFACE

This report is the result of an effort to determine the advantages and disadvantages of present sound ray tracing techniques and to investigate the possible replacement of these with more exact procedures. As an adjunct to this investigation, an analysis of sound pressure levels was begun, also with an eye toward modifying or even replacing the present sound pressure level computation procedures with procedures of more exactitude.

The report is divided into three parts: background and theory, computer program, and results. By far the most interesting section is the one on results of the studies. In this section are to be found typical atmospheric conditions, along with analyses of these atmospheric situations, both by the present methods and by the methods as developed in this present report. Numerous comparisons are made between the two methods, with sometimes startling results. In order to fully understand this study and appreciate the results, one should study the preceding reports in this series. One deficiency is that no adequate, comprehensive "users manual" is given to ease the use of the computer program.

This work was done under contract number NAS8-11348 by Kaman-Nuclear under the technical Supervision of O. E. Smith, Chief, Terrestrial Environment Branch, Aerospace Environment Division, Aero-Astrodynamics Laboratory, Marshall Space Flight Center.

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SUMMARY

Obtained by ray-tracing methods, the diagnosed strength of noise fields depends partly on just the way in which the observed atmosphere is to be represented. Along the local vertical, a linearized variation of horizontal wind- and sound-speed introduces certain characteristics in the outward ranging of sound and its intensity. Such a straight-stepped representation of aerological data has been customary in meteorological practice, as a convenient approximation to the smoothly changing atmosphere. Descriptive of the real atmosphere, a non-linear representation of the aerological observations is nevertheless easily obtained. These representations lead to two methods for estimating sound intensity. This report discusses these methods and compares the results obtained by them.

CHAPTER I

CONSIDERATIONS IN PROGRAMMING SOUND INTENSITY ESTIMATES

CHAPTER I

The general problem consists in diagnosing and predicting the noise fields generated by the static firings of rocket engines. These fields vary according to the atmospheric conditions. In addition, from such firings, the outward ranging of sound may be affected significantly and undesirably just by the way in which the horizontal wind- and sound-speed is represented along the local vertical.

To assess this effect and then to account for it properly involves a number of important considerations (often overlooked), before the general problem can really be solved successfully. This chapter introduces the study-report of the general problem by stating what these prerequisites are and by showing exactly how they may be correctly satisfied.

To assess this effect it is necessary, for example, to preserve the derivative character of the landing distance of sound with respect to the initial ray inclination around data levels in the linear representation of wind- and sound-speed. The non-linear representation involves additional considerations. One involves the description of vertex coordinates in terms of the non-linear coefficients; another, the joining of the non-linear curve-segments for the best fit to the data points. These considerations prepare the way for the basic one, the integration of the ray equation.

The results are converted into computational relations which are introduced into the program for solving the general problem. This program is listed in Chapter II. Some results of its application are presented in Chapters III and IV. But, the primary purpose of this chapter is to facilitate the understanding of the program listed in Chapter II.

A. VERTEX COORDINATES IN TERMS OF PARABOLIC COEFFICIENTS

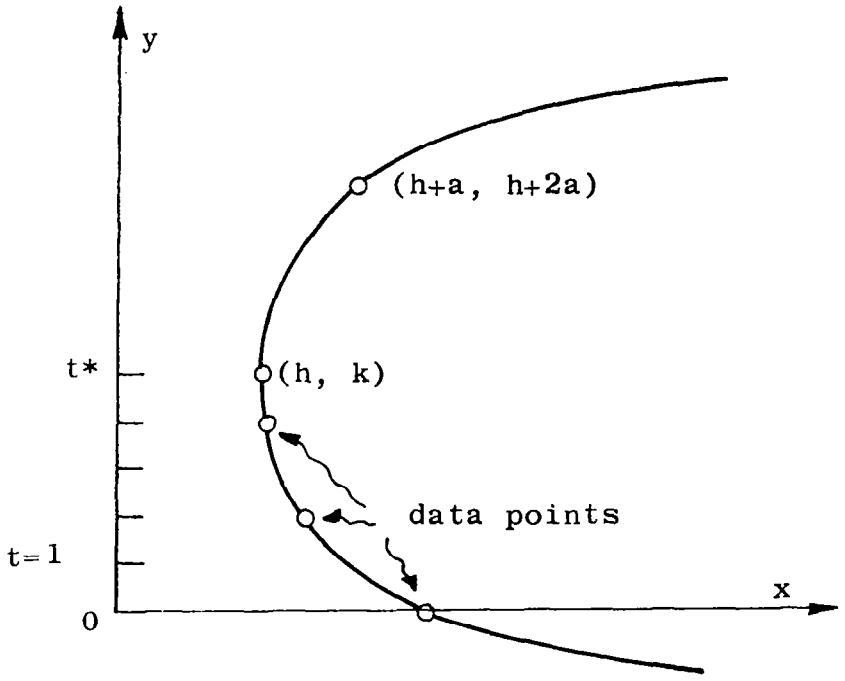

Figure 1
Atmospheric Sounding

Referring to Figure 1, we may transform the standard parabolic relation (whose symbols are defined in Figure 1)

$$(y-k)^2 = 2a(x-h)$$

to its normal form

$$x = A + By + Cy^2 \ .$$

Expanding equation (1) and rearranging to the form of equation (2) we have

$$x = \frac{k^2+2ah}{2a} - \frac{k}{a}y + \frac{1}{2a}y^2;$$

whereupon, from equations (2) and (3), we obtain

$$\left.\begin{aligned} A &= \frac{k^2 + 2ah}{2a} \quad , \\ B &= -\frac{k}{a} \quad , \text{ and} \\ C &= \frac{1}{2a} \quad . \end{aligned}\right\} \tag{4}$$

It also becomes convenient to transform equation (2) to the form

$$\left.\begin{aligned} x &= A^* + Q\,(z-z_*)^2 \quad , \text{ or} \\ x &= A^* + G^*\,(y-B^*)^2 \quad ; \quad \text{i.e.,} \end{aligned}\right. \tag{5}$$

equation (2) becomes

$$x = A - \frac{B^2}{4C} + C\left(y+\frac{B}{2C}\right)^2 \quad . \tag{6}$$

Comparing equations (5) and (6) we see that

$$A^* = A - B^2/4C \tag{7}$$

$$Q = G^* = C \tag{8}$$

$$z_* = B^* = -B/2C \tag{9}$$

From equations (4) and (7) it is evident that

$$B^2 = \frac{k^2}{a^2} \quad ,$$

$$\frac{B^2}{4C} = \frac{k^2}{a^2}\,\frac{2a}{4} = \frac{k^2}{2a} \quad ,$$

$$A - \frac{B^2}{4C} = \frac{k^2+2ah}{2a} - \frac{k^2}{2a} = h.$$

and by equation (7), it is seen that

$$h = A^*, \text{ and}$$

$$k = -(-\frac{k}{a})\frac{2a}{2} = -\frac{B}{2C}$$

and that, from equation (9),

$$k = B^* = z_* = (= t^*)$$

And $Q=G^* = C = 1/2a$ is the curvature of the parabolic sounding. For G^* positive, the parabolic apex is a minimum in, say, $v = c+u$; for G^* negative, a maximum.

In Figure 1 and equations (7-9) and these relations, x and y may be replaced by $v = c+u$ and t. Then equations (7), (8) and (9) become arithmetic statements 699+10, 11, and 12:

```
AA(1) = A1 - (B1**2) / (4*C1)

GG(1) = C1

ZZ(1) = -B1/2 *C1    .
```

The AA(1) is the sound-propagation speed v (m/s)at a vertex of the parabolic sounding-curve; ZZ(1), its height from sea-level. These vertex coordinates are expressed in terms of the parabolic coefficients. So, to find the vertex, or apex coordinates, we need to evaluate these parabolic coefficients. This may be done as follows

B. EVALUATION OF THE PARABOLIC COEFFICIENTS

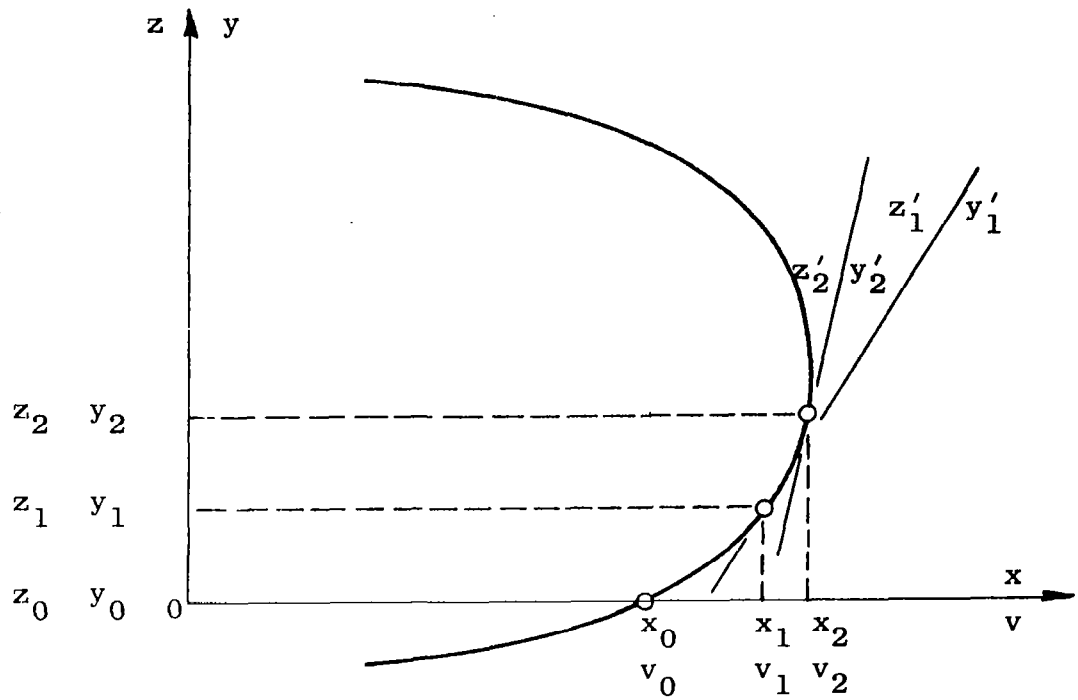

Figure 2

From equation (2) and Figure 2 - replacing y by z (for vertical z- coordinate), and x by v (for the horizontal v-coordinate)

$$x_1 = A + Bz_1 + Cz_1^2 \quad , \tag{10}$$

$$x_2 = A + Bz_2 + C_{z_2}^2 \quad , \text{ which, when} \tag{11}$$

differentiated, becomes

$$x_2' = B + 2\,Cz_2 \quad . \tag{12}$$

Subtracting equation (11) from (10),

$$x_2 = x_1 = B(z_2-z_1) + C(z_2^2 - z_1^2) \quad ,$$

$$\frac{x_2 - x_1}{z_2 - z_1} = B+C(z_2+z_1) \quad . \tag{13}$$

And, subtracting equation (13) from equation (12),

$$x_2' - \frac{x_2 - x_1}{y_2 - y_1} = 2Cz_2 - C(z_2 + z_1),$$

$$= C(z_2 - z_1) \text{ ; whence}$$

$$C = \left(x_2' - \frac{x_2 - x_1}{z_2 - z_1}\right) \frac{1}{z_2 - z_1} \quad . \tag{14}$$

Equation (14) is arithmetic statement 699+7:

```
C1 =  (F2P - FS) / DZ .
```

From equations (13) and (14)

$$B = \frac{x_2 - x_1}{z_2 - z_1} - \left(x_2' - \frac{x_2 - x_1}{z_2 - z_1}\right) \frac{z_2 + z_1}{z_2 - z_1} \quad ,$$

$$= \frac{x_2 - x_1}{z_2 - z_1} \left(1 + \frac{z_2 + z_1}{z_2 - z_1}\right) - x_1' \frac{z_2 + z_1}{z_2 - z_1} \quad ,$$

$$= \frac{x_2 - x_1}{z_2 - z_1} \frac{2z_2}{z_2 - z_1} - x_2' \frac{z_2 + z_1}{z_2 - z_1} \quad . \tag{15}$$

Equation (15) is arithmetic statement 699+8:

```
B1 = FS*2 . *Z2/DZ
     - F 2 P * (Z1 + Z2) / DZ
```

Finally, from equation (2)

$$A = x_1 - Bz_1 - C z_1^2 \quad ,$$

$$= x_1 - \frac{2(x_2 - x_2)(z_1)(z_2)}{(z_2 - z_1)^2}$$

$$+ \frac{x_2' (z_2 + z_1) z_1}{z_2 - z_1}$$

$$- \left(x_2' - \frac{x_2 - x_1}{z_2 - z_1}\right) \frac{z_1^2}{z_2 - z_1} ,$$

$$= x_1 + z_1 x_2' \left(\frac{z_2 + z_1 - z_1}{z_2 - z_1}\right)$$

$$- z_1 \left(\frac{x_2 - x_1}{z_2 - z_1}\right) \left(\frac{2 z_2 - z_1}{z_2 - z_1}\right) ,$$

$$A = x_1 + \left(z_2 x_2' - \frac{(x_2 - x_1)(2 z_2 - z_1)}{z_2 - z_1}\right) \frac{z_1}{z_2 - z_1} . \qquad (16)$$

This equation (16) is arithmetic statement 699+10:

```
A1 = F1 + (Z2 * F 2 P - FS *(2 * Z2 - Z1)) * Z1/DZ
```

C. OPTIMAL FITTING OF PARABOLIC CURVE-SEGMENTS TO DATA POINTS

In the previous report it has been shown that the parabolic curve segments mutually adjusted for best fit to the data points join one another midway between these points. So, in the code we introduce these half layers. For each data-and mid-point we express the height parameters and variables in the parabolic coefficients as multiples of the superjacent half-layer thickness as a height unit.

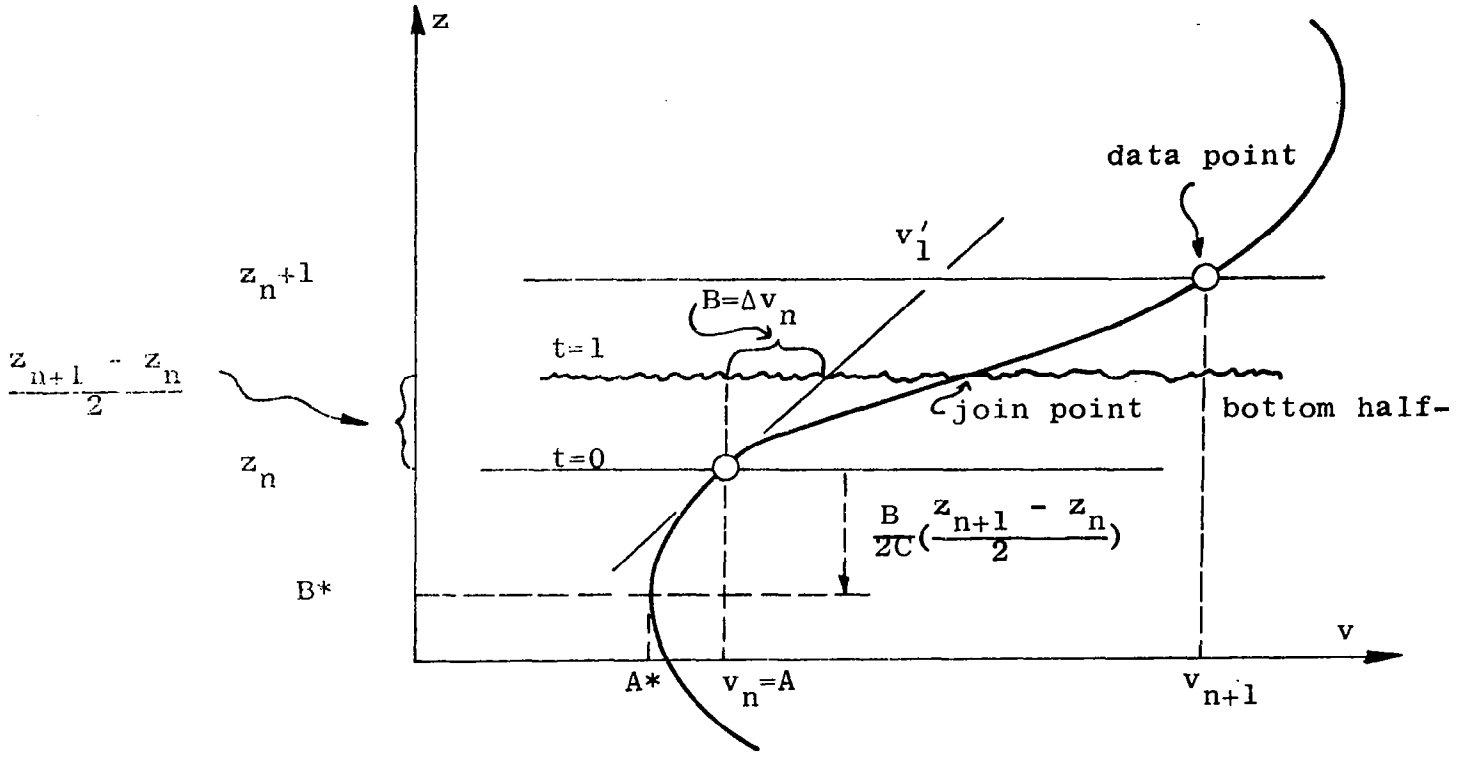

Figure 3

Consider first a bottom half-layer, as shown in Figure 3. There, the parabolic coefficients can be evaluated from observational data by the equations given on page 112 of the referenced report; viz.,

$$A = V_n ,$$

$$B = v_n' (z_{n+1} - z_n)/2 ,$$

$$C = \left[(v_{n+1}-v_n) - v_{n+1}'+3v_n')(z_{n+1}-z_n)/4\right]2 .$$

Arithmetic statements 700-8 to 700-6 are obtained from these equations (17-19) respectively:

```
A1 = F1
B1 = F1P * DZ/2 .
C1 = (DF - (F2P + 3.*F1P) * DZ/4.)/2 .
```

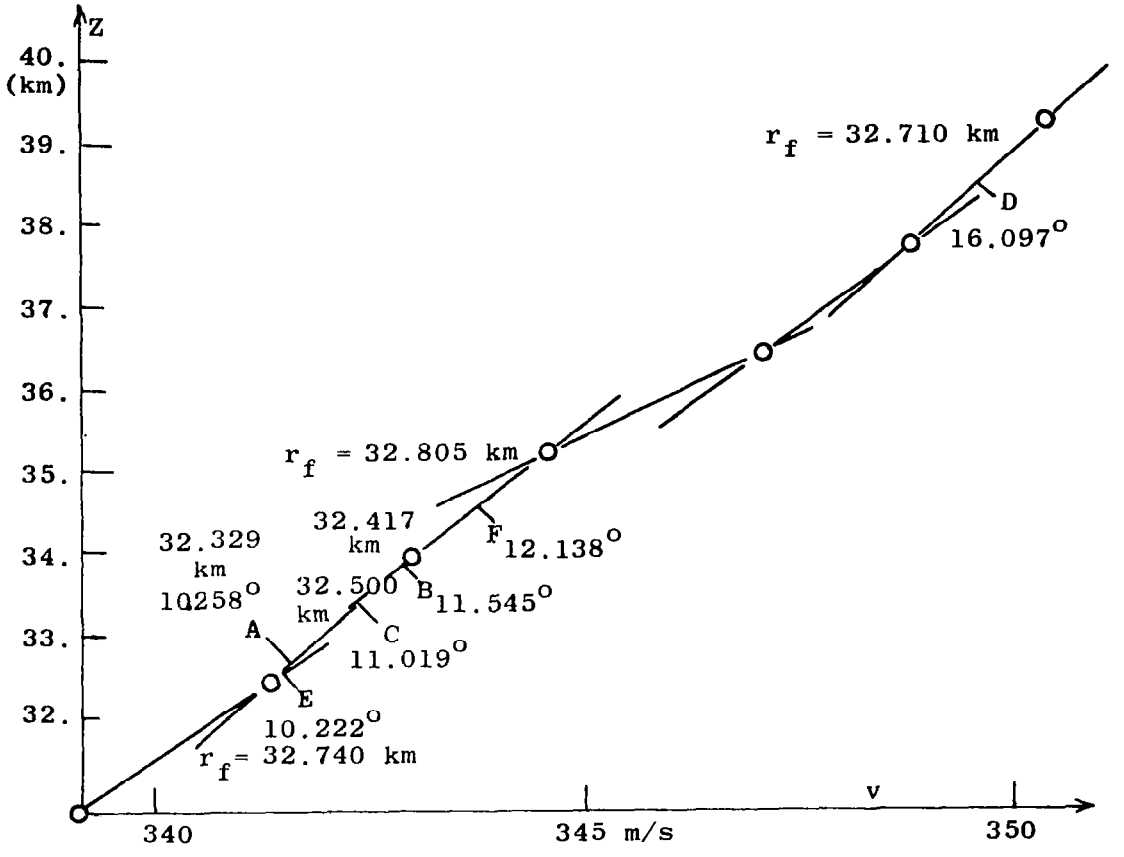
Z
40.
(km)
39.
38.
37.
36.
35.
34.
33.
32.
r_f = 32.710 km
D
16.097°
r_f = 32.805 km
32.417
km
F
12.138°
32.329
km
10258°
32.500
km
B
11.545°
A
C
11.019°
E
10.222°
r_f = 32.740 km
v
340
345 m/s
350

FIGURE 42

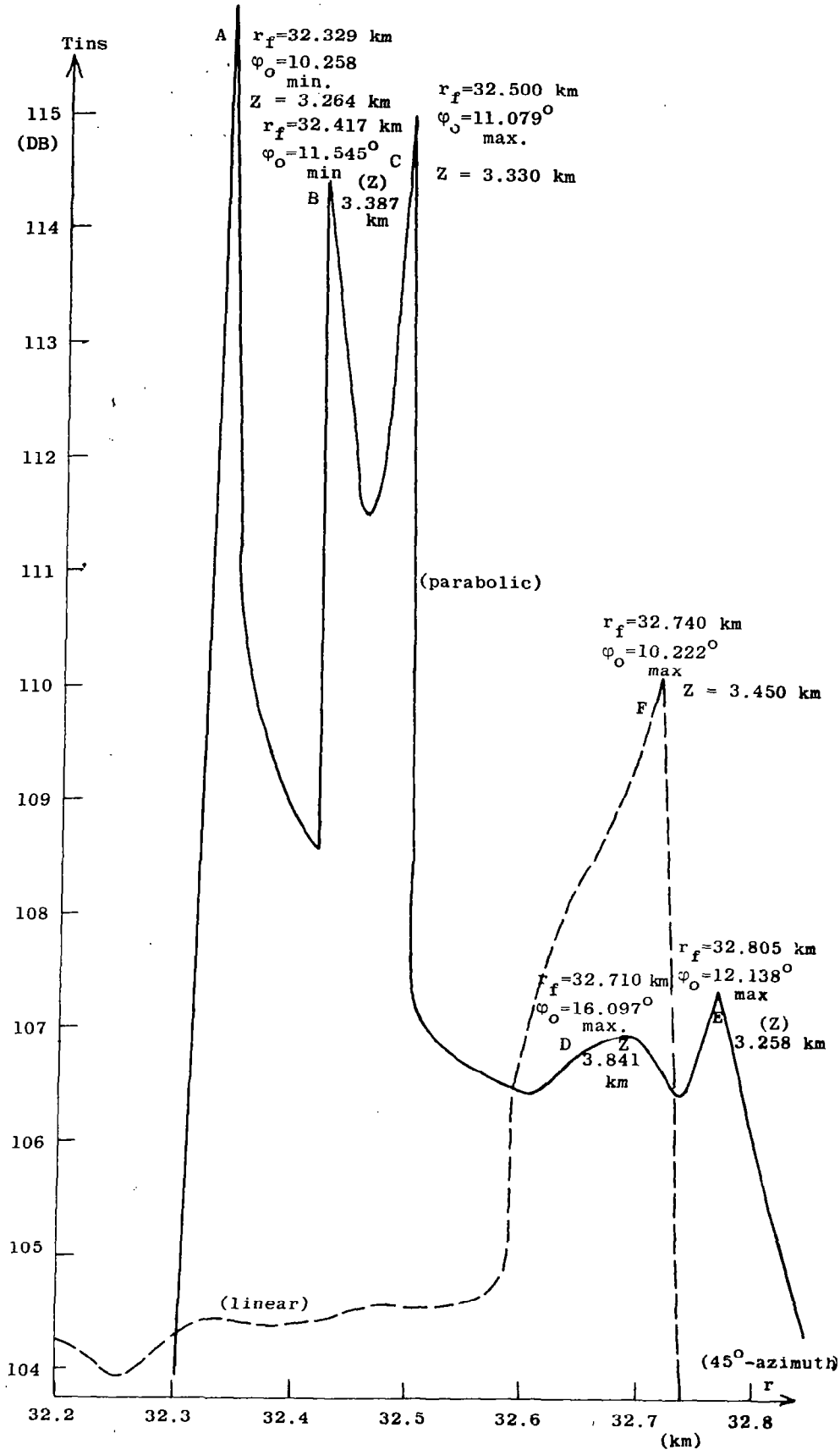
Tins
115
(DB)
114
113
112
111
110
109
108
107
106
105
104
A
r_f=32.329 km
φ_o=10.258
min.
Z = 3.264 km
r_f=32.417 km
φ_o=11.545°
min
B
C
(Z)
3.387
km
r_f=32.500 km
φ_o=11.079°
max.
Z = 3.330 km
(parabolic)
r_f=32.740 km
φ_o=10.222°
max
F
Z = 3.450 km
r_f=32.805 km
φ_o=12.138°
max
E
(Z)
3.258 km
r_f=32.710 km
φ_o=16.097°
max.
D
Z
3.841
km
(linear)
(45°-azimuth)
r
32.2
32.3
32.4
32.5
32.6
32.7
32.8
(km)

FIGURE 43